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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, *Secretary*
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ABSTRACT

This report provides a brief description and running instructions for the one-dimensional Monte Carlo code ZTRAN. The program is used to calculate the transport of electrons and photons in heterogeneous multi-layer media.

1. Introduction

This report pertains to the Monte Carlo program code ZTRAN which has been developed as a tool for calculating the transport of electrons and photons through multi-layer media. The code is a generalization of an earlier Monte Carlo code, ETRAN,[1-9] which applies to a homogeneous medium. In ZTRAN, the medium is assumed to consist of several adjacent plane-parallel layers, each of which can have a different composition. The layers are assumed to be unbounded laterally, and the treatment is one-dimensional, including only a single spatial variable along the direction of stratification of the medium. The output of the ZTRAN code consists of information about the spatial distribution of energy deposition and the electron and photon fluxes (differential in energy) within the multi-layer medium, and the reflection and transmission of these radiations from the medium.

Some results with ZTRAN have already been published.[10-12] The purpose of this report is to provide information which will facilitate the use of the code by others. Brief descriptions are given of the Monte Carlo model, and of the input and output of ZTRAN. Illustrative results are shown pertaining to energy deposition. Appendix A contains running instructions, in the form of a detailed listing of the input variables including their format and meaning. The purpose of the various subroutines in ZTRAN is also briefly indicated. Appendix B presents a listing of the input and output for a typical ZTRAN run.

2. Monte Carlo Model

The ZTRAN program is based on the same Monte Carlo model, and uses the same cross sections, as ETRAN. In fact, it shares with ETRAN the data base of pre-processed cross sections provided by the DATAPAC code.[2] Successive photon interactions are sampled individually in direct analogy to the physical processes (Compton scattering, photoelectric absorption, and pair production). The much more numerous elastic and inelastic interactions between electrons and atoms are treated according to a "path-segment" model. The electron trajectories are divided into many segments in each of which numerous interactions occur. The net angular deflection from the combined effect of the elastic and inelastic collisions in a single segment is sampled from the Goudsmit-Saunderson multiple-scattering distribution, using — as the underlying elastic scattering cross section — the Mott cross section modified for screening according to Molière. The total energy loss in a segment is sampled from the Landau straggling distribution, and from the appropriate bremsstrahlung cross sections.

The Monte Carlo model takes into account all secondary radiations, including knock-on electrons from electron-impact ionization events, bremsstrahlung and characteristic x rays, Compton electrons, photoelectrons, electron-positron pairs, and annihilation radiation. The calculation follows all generations of electrons and photons in the target with energies above chosen cut-off values. A weighting scheme allows for the sampling of bremsstrahlung photon histories in excess of the natural production rates so that statistical fluctuations in the bremsstrahlung results can be reduced without an increase in the number of time-consuming electron histories. The statistical accuracy of the photon results is also improved by scoring for each collision point in the photon history the probability that the photon crosses the boundaries of interest without further interaction (collision-density method).

A number of options can be selected which allow for variations of the basic Monte Carlo model. These are included to permit model studies involving various approximations, and are not necessarily recommended for production runs. These variations include, for example, treating electron energy losses in the continuous-slowing-down approximation, not following energetic knock-on electrons (delta-rays), and not following secondary photons (bremsstrahlung, characteristic x rays, annihilation radiation). A complete listing of those options is given in Appendix A.

3. Input

The input for ZTRAN is organized in a manner similar to that for ETRAN, and consists of three parts: (a) run parameters, (b) photon cross-section data, and (c) electron cross-section data. Items (a) and (b) are read in on logical unit 5 in card-image format. Item (c) is read in on logical unit 9, and consists of a data file generated by the pre-processing program DATAPAC.

DATAPAC must be run with appropriate input parameters so as to include the materials and energies of interest. These input parameters are not discussed here, but are described in Ref. 2.

A listing of the input from categories (a) and (b) is given in Appendix A. The run parameters include those for selecting the Monte Carlo model options and the parameters which determine the selection and size of the target layers, the type of incident radiation (electron or photons), the nature of initial spectrum (monoenergetic, continuous or discrete spectra), the type of initial angular distribution (mono-directional, isotropic, cosine-law), the position of source plane (external or internal), and the type of information and scoring regions desired.

4. Output

The print-out from ZTRAN includes an echo of much of the input data, some auxiliary intermediate information, and the various results including: (a) number and energy transmission and reflection coefficients for electrons and for photons crossing the target slab boundaries; (b) energy and charge deposition as a function of depth in the target; (c) spectra of electron and of photon fluence, as a function of depth, in the target; (d) spectra of energy absorbed in the target slabs; and (e) energy spectra, angular distributions, and joint energy and angular distributions of electrons and of photons crossing slab boundaries in both forward and backward directions.

The print-out includes sufficient headings so that it is largely self-explanatory. In lieu of a lengthy description of the ZTRAN output, we give in Appendix B the printout for a sample run, which was in fact used to solve one of the illustrative problems described in section 5.

5. Illustrative Applications of ZTRAN

As a first example, we illustrate the application of ZTRAN to the calculation of depth-dose distributions from 60-MeV electron beams in composite media. Figure 1 compares the depth-dose curves in homogeneous water, homogeneous aluminum, and a composite target consisting of 2 g/cm^2 of aluminum followed by a semi-infinite water medium. Figures 2 and 3 give corresponding results for copper-water and lead-water combinations.

A second example pertains to the use of dye-film dosimeters to determine the absorbed dose from low-energy electron beams. The assumed configuration, as indicated in figure 4, involves a 400-keV electron beam that passes through a 1-mil titanium window and 10 cm of air, traverses a 2-mil nylon-based dye-film dosimeter, and is backscattered or stopped by a thick backing plate. The ZTRAN calculation produces, among other quantities, the energy deposited in the film dosimeter, and the charge deposited in the backing plate, per incident electron. Table 1 gives these results for various backing-plate materials. Results of this type could be used, for example, to calibrate the dye-film dosimeter or to calibrate the current from the accelerator.

6. Acknowledgment

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7. References

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Table 1. Energy and charge deposition from a 400-keV electron beam incident on the composite target of figure 4. The results include:

(a) The ratio D/J_0 of the absorbed-dose rate in the dye-film dosimeter to the electron current incident on the titanium window;

(b) The "relative dose," defined as the dose rate D in the presence of the specified metal backing plate divided by the corresponding dose rate in the presence of a nylon backing plate;

(c) The ratio J/J_0 of the current induced in the backing plate to the current incident on the titanium window;

(d) The ratio D/J of the dose rate in the dye-film dosimeter to the current induced in the backing plate.

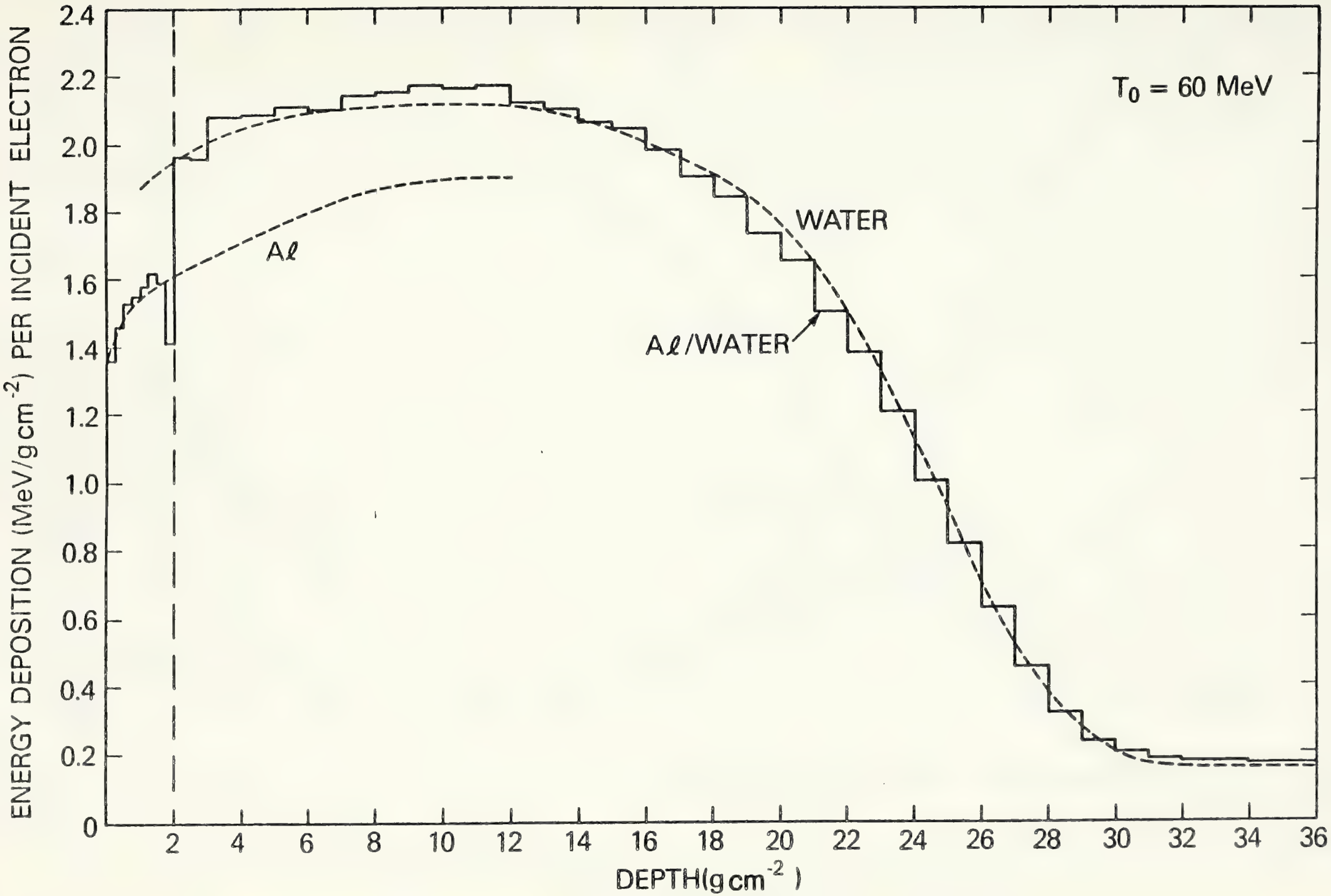
Backing Material	D/J_0 (MeV g^{-1} cm^2)	Relative Dose	J/J_0	D/J (MeV g^{-1} cm^2)
nylon	4.56	1.00	0.847	5.38
Al	5.39	1.18	0.765	7.05
Fe	6.41	1.41	0.657	9.76
Cu	6.61	1.45	0.638	10.4
Ag	7.32	1.61	0.559	13.1
Au	8.15	1.79	0.464	17.6
U	8.50	1.86	0.426	20.0

Fig. 1 Comparison of depth-dose distributions from a 60-MeV electron beam. The dashed curves represent the distributions in homogeneous semi-infinite aluminum or water media. The histogram represents the distribution in a multi-layer medium consisting of 2 g/cm^2 of aluminum followed by a semi-infinite water layer.

Fig. 2 Same as figure 1, but for a copper-water combination.

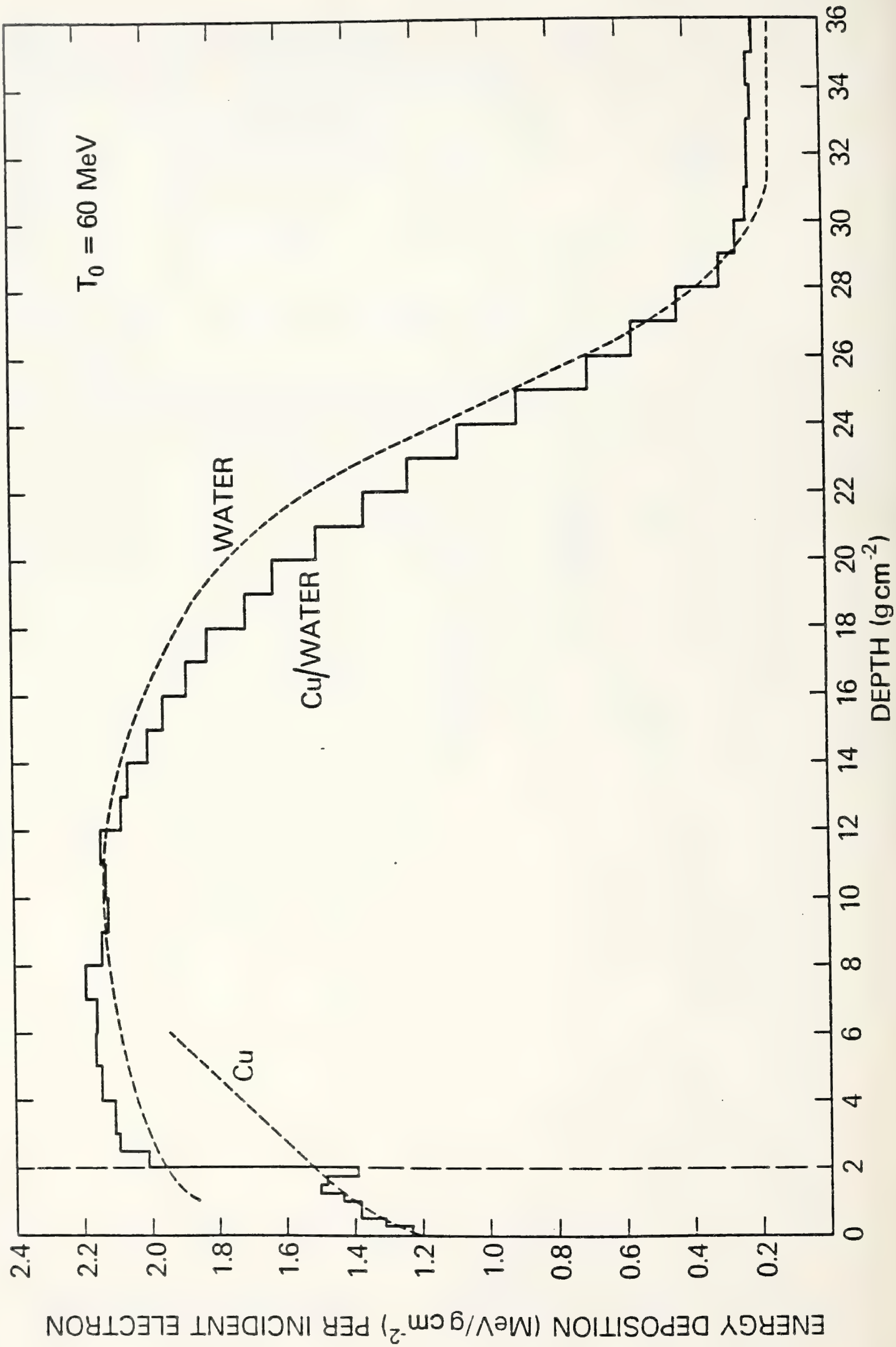
Fig. 3 Same as figure 1, but for a lead-water combination.

Fig. 4 Target arrangement for the film dosimeter study.



ENERGY DEPOSITION (MeV/g cm^{-2}) PER INCIDENT ELECTRON
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
T_0 = 60 MeV
Aℓ
WATER
Aℓ/WATER
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
DEPTH(g cm^{-2})

Fig. 1


$T_0 = 60$ MeV
WATER
Cu/WATER
Cu
DEPTH (g cm^{-2})
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
ENERGY DEPOSITION (MeV/g cm^{-2}) PER INCIDENT ELECTRON
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4

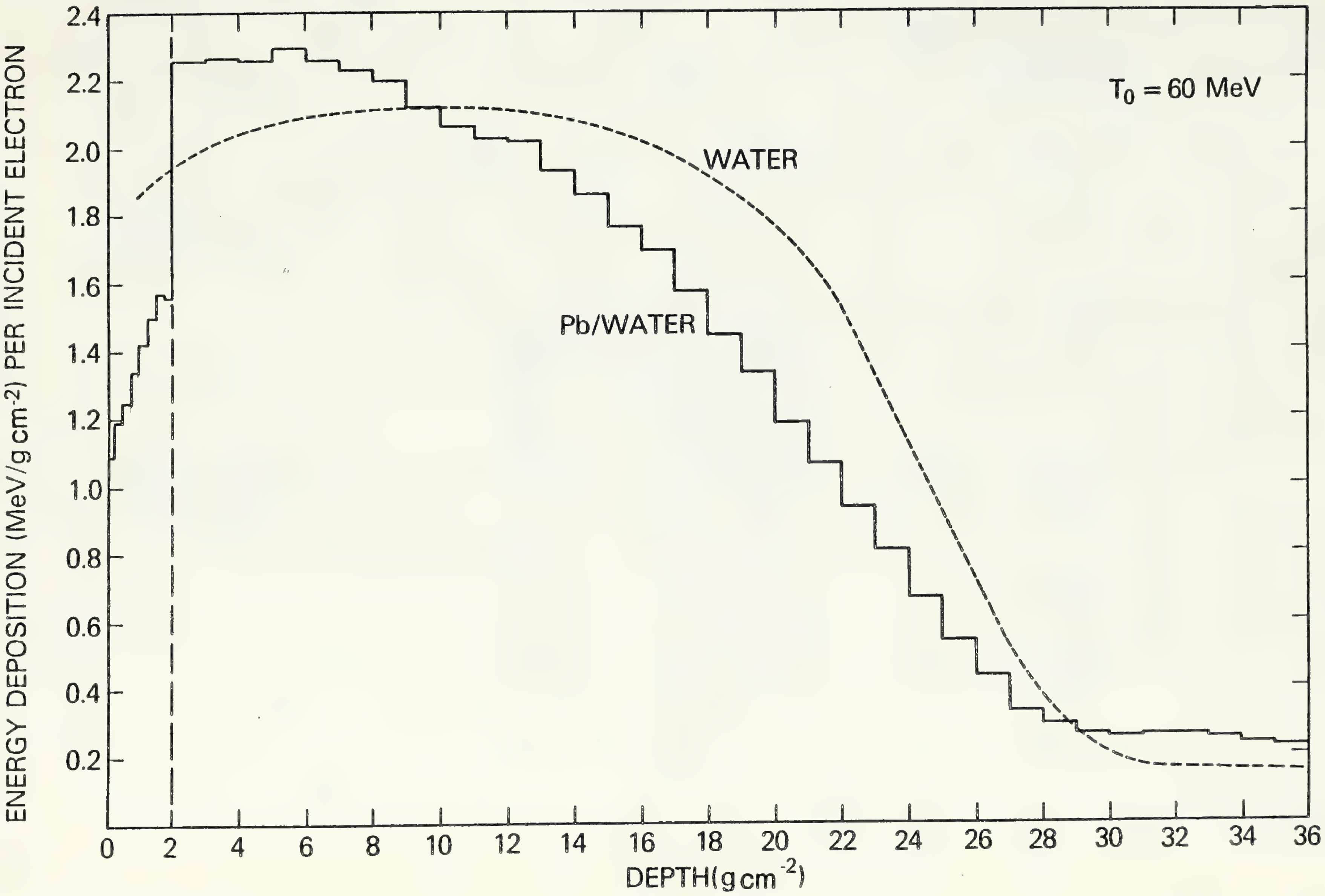

$T_0 = 60$ MeV
WATER
Pb/WATER
ENERGY DEPOSITION (MeV/g cm-2) PER INCIDENT ELECTRON
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
DEPTH(g cm-2)

Fig. 3

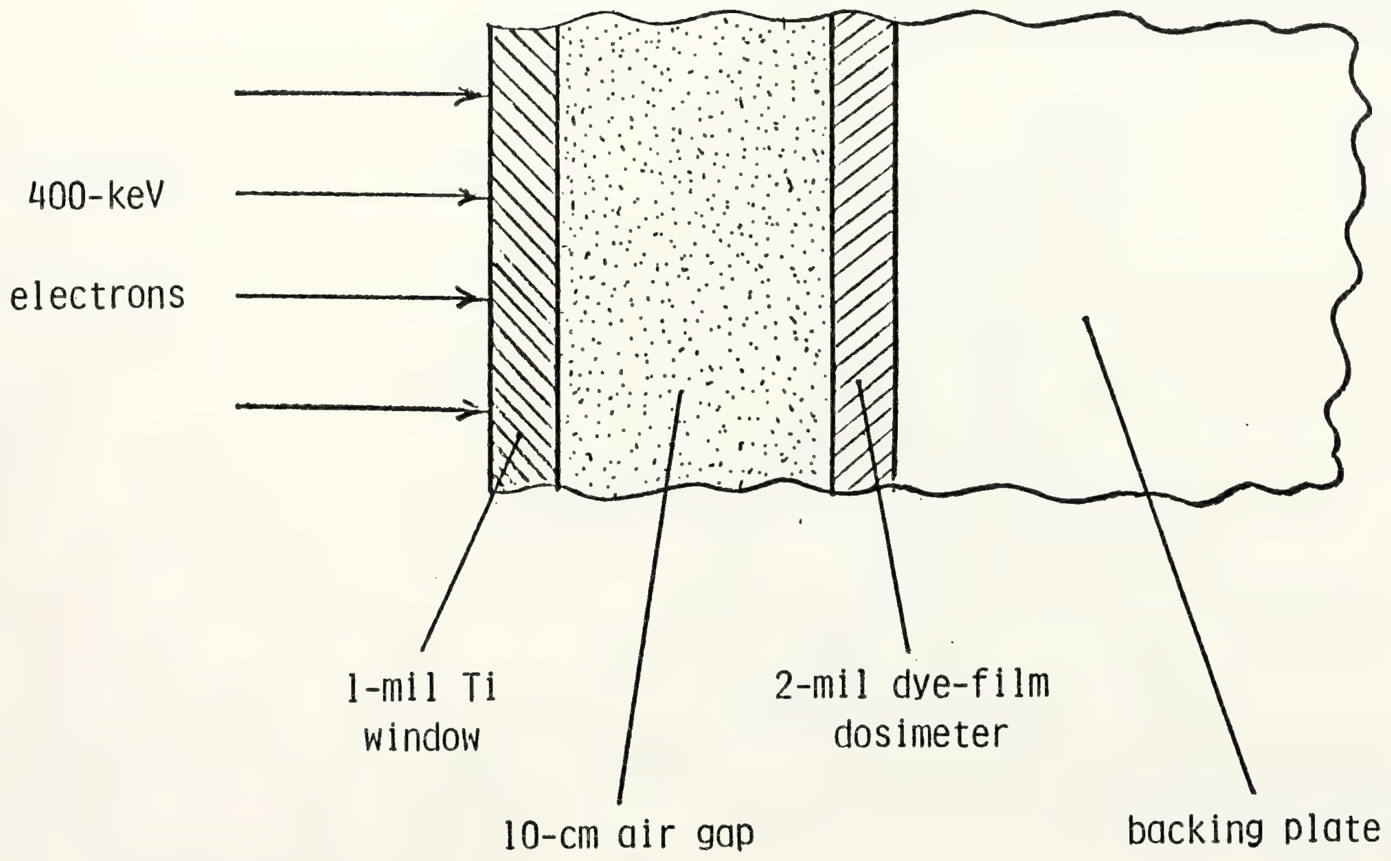

400-keV
electrons
1-mil Ti
window
10-cm air gap
2-mil dye-film
dosimeter
backing plate

Fig. 4

APPENDIX A

FORMAT FOR CARD IMAGE INPUT (LOGICAL UNIT 5) FOR ZTRAN 4C

CROSS SECTION INPUT

```
MSET                                    I6
      LOOP TO ## MSET TIMES
NSET,NTAB,NEDG                          3I6
MPAIR,(MTAX(I),I=1,NTAB)                12I6
((EB(M,I),M=1,MTAX(I)),I=1,NTAB)        6F12.6 (NEW CARD FOR EACH I)
((ATB(M,I),M=1,MTAX(I)),I=1,NTAB)       6F12.6 (NEW CARD FOR EACH I)
((SURVB(M,I),M=1,MTAX(I)),I=1,NTAB)     6F12.6 (NEW CARD FOR EACH I)
(PAIRB(M),M=1,MPAIR)                    6F12.6
      LOOP TO # NEDG TIMES
EDGK,PKEG,WK                            3F12.6
NUMK,NUMA                               2I6
(EK(N),N=1,NUMK)                        6F12.6
(RK(N),N=1,NUMK)                        6F12.6
(EAUG(N),N=1,NUMA)                      6F12.6
(RAUG(N),N=1,NUMA) #                    6F12.6
DETOUR,EXCI1,AVGKE  ##                  3F12.6
```

RUN PARAMETER INPUT

```
IRNMAX                                  I6
```

THE PARAMETER IRNMAX GIVES THE NUMBER OF RUNS TO BE MADE WITH THE CROSS SECTIONS FOR THE GIVEN SET OF MATERIALS. FOR EACH OF THE RUNS, INPUT PARAMETERS MUST BE SUPPLIED AS GIVEN BELOW. INPUT DATA INDICATED BY (*) ARE TO BE INCLUDED ONLY UNDER CERTAIN OPTIONS CONTROLED BY THE VALUES OF OTHER INPUT PARAMETERS (SEE MEANING OF INPUT VARIABLES).

```
COMMENT                                 72H
NRUN,INC,ISTRG,INOK,IPHOT,IBAD,
     IDES,ITER,IPSC,IPUN,ITAPE          11I6
LMAX,ITMK,JMAX,IPMK,JPMAX,ISMK,
     JSMAX,IAMK,KMAX,IBMK,KPMAX,
     LMIX                               12I6
IMAX,LDEP,LZMAX,LEFLUX,LEFMAX,
     NCYC,LPFLUX,LPFMAX,NPCYC,
     NFCOS,LBIN                         11I6
INRAN                                   I12
TIN,TCUT,TPCUT,TSAVE,ANGIN,ZIN          6F12.5
(*) JSPEC,ISAM,COMMENT                  2I6,66H
(*) (SPECIN(J),J=1,JSPEC)               6F12.5
(*) (ESP(J),J=1,JSPEC)                  6F12.5
BNUM,XNUM,DLIM                          3F12.5
(B(L),L=1,LMAX)                         6F12.5
(MATNO(L),L=1,LMAX)                     6I12
(LESPEC(L),L=1,LMAX)                    12I6
(LPSPEC(L),L=1,LMAX)                    12I6
(*) (TMARK(J),J=1,JMAX)                 6F12.5
(*) (PMARK(J),J=1,JPMAX)                6F12.5
(*) (SMARK(J),J=1,JSMAX)                6F12.5
(*) (AMARK(K),K=1,KMAX)                 6F12.5
(*) (BMARK(K),K=1,KPMAX)                6F12.5
(*) (BD(L),L=1,-LZMAX)                  6F12.5
(*) (BF(L),L=1,-LEFMAX)                 6F12.5
(*) (FMARK(J),J=1,JFMAX)                6F12.5
(*) (BPF(L),L=1,-LPFMAX)                6F12.5
(*) (FPMARK(J),J=1,JPFMAX)              6F12.5
```

MEANING OF INPUT VARIABLES FOR PROGRAM ZTRAN 4C

MSET	NUMBER OF MATERIALS FOR WHICH CROSS SECTIONS ARE TO BE READ.
NSET	NUMBER OF DATAPAC SET FOR THE DESIRED MATERIAL THAT IS PRESENT ON THE INPUT FILE (UNIT 9).
NTAB	NUMBER OF ENERGY REGIONS FOR WHICH GAMMA RAY CROSS SECTION TABLES ARE GIVEN (EQUALS NUMBER OF ABSORPTION EDGES + 1).
NEDG	NUMBER OF SHELLS FOR WHICH CHARACTERISTIC X-RAY AND AUGER EMISSION WILL BE CONSIDERED.
MPAIR	NUMBER OF ELEMENTS IN PAIRB ARRAY.
MTAX(I)	NUMBER OF ELEMENTS IN I'TH TABLE OF EB ARRAY.
EB	LIST OF ENERGIES (MEV, DESCENDING ORDER) AT WHICH GAMMA RAY CROSS SECTIONS ARE TABULATED.
ATB	TOTAL ATTENUATION COEFFICIENT (CM**2/G).
SURVB	SUM OF COMPTON SCATTERING AND PAIR PRODUCTION COEFFICIENT DIVIDED BY TOTAL ATTENUATION COEFFICIENT (EQUALS PROBABILITY THAT AN INTERACTION WILL NOT RESULT IN PHOTOELECTRIC ABSORPTION).
PAIRB	RATIO OF COMPTON SCATTERING COEFFICIENT TO SUM OF COMPTON SCATTERING AND PAIR PRODUCTION COEFFICIENTS (EQUALS PROBABILITY THAT A SCATTERING RATHER THAN A PAIR PRODUCTION EVENT OCCURS, EXCLUDING THE POSSIBILITY OF PHOTOELECTRIC ABSORPTION).
EDGK	SHELL BINDING ENERGY (IN MEV).
PKEG	SHELL PHOTOEFFECT EFFICIENCY. (EQUALS RATIO OF PHOTOELECTRIC CROSS SECTION FOR SHELL TO TOTAL PHOTOELECTRIC CROSS SECTION. THIS RATIO IS ASSUMED CONSTANT AND RELATES TO ENERGIES ABOVE THE K-SHELL BINDING ENERGY, I.E., WHERE ALL SHELLS CONTRIBUTE. AT LOWER ENERGIES, NON-CONTRIBUTING SHELLS ARE AUTOMATICALLY ACCOUNTED FOR.)
WK	SHELL FLUORESCENCE EFFICIENCY.
EK	ENERGIES (IN MEV) OF CHARACTERISTIC X-RAYS.
RK	CUMULATIVE PROBABILITY DISTRIBUTION FOR X-RAY ENERGIES.
EAUG	ENERGIES (IN MEV) OF AUGER ELECTRONS.
RAUG	CUMULATIVE PROBABILITY DISTRIBUTION FOR AUGER ELECTRON ENERGIES.

THE PRESENT SCHEME OF X-RAY AND AUGER EMISSION IS NEITHER COMPLETE NOR GENERAL. FOR EXAMPLE, THE REARRANGEMENT OF THE ATOM FOLLOWING IONIZATION EVENTS IS NOT INCLUDED (E.G. L-SHELL EMISSION FOLLOWING K-SHELL FILLING, ETC.). IF A MATERIAL IS A COMPOUND OR MIXTURE, SHELLS BEYOND THE K-SHELL SHOULD NOT BE CONSIDERED. IN THIS CASE, THE K-IONIZATION EVENTS CAN BE CALCULATED ONLY FOR THE ELEMENT WITH LARGEST Z. THE VARIABLES EDGK, WK, EK, RK, EAUG AND RAUG SHOULD BE GIVEN THE VALUES FOR THIS ELEMENT, AND PKEG GIVEN THE VALUE OF THE K-SHELL PHOTOEFFECT EFFICIENCY FOR THIS ELEMENT MULTIPLIED BY PROBABILITY THAT THE PHOTOELECTRIC ABSORPTION TAKES PLACE IN THE LARGEST-Z ELEMENT. THIS PROBABILITY IS

(W*SIGPE)LARGEST-Z / SUMMATION(W*SIGPE),

WHERE W IS THE FRACTION BY WEIGHT AND SIGPE THE PHOTOEFFECT CROSS SECTION IN BARNS/ATOM FOR AN ELEMENT. IN GENERAL, THIS PROBABILTY IS A FUNCTION OF PHOTON ENERGY. THEREFORE, AN AVERAGE OR EFFECTIVE PROBABILITY, SUITABLE TO THE PROBLEM CONSIDERED, SHOULD BE DETERMINED.

DETOUR	RATIO OF PRACTICAL TO MEAN RESIDUAL ELECTRON RANGE.
EXCI1	MEAN EXCITATION ENERGY (KEV) OF THE MEDIUM FOR COLLISION ENERGY-LOSS STRAGGLING. IF OMITTED, VALUE IS ESTIMATED INTERNALLY.
AVGKE	MEAN KINETIC ENERGY (KEV) OF ATOMIC ELECTRONS IN THE MEDIUM, USED IN EVLUATION OF COLLISION ENERGY-LOSS STRAGGLING. IF OMITTED, VALUE IS ESTIMATED INTERNALLY.
IRNMAX	NUMBER OF RUNS TO BE MADE.
COMMENT	ANY MESSAGE CONSISTING OF UP TO 72 HOLLERITH CHARACTERS.
NRUN	RUN NUMBER (USED ONLY FOR IDENTIFICATION).
INC	1 CASCADE INITIATED BY ELECTRONS INCIDENT ON TARGET.

	2	CASCADE INITIATED BY PHOTONS INCIDENT ON TARGET.
ISTRG	1	ELECTRON ENERGY LOSS STRAGGLING TAKEN INTO ACCOUNT.
	2	ELECTRON ENERGY LOSS TREATED IN CONTINUOUS-SLOWING-DOWN APPROXIMATION.
INOK	1	KNOCK-ON DELTA-RAY HISTORIES ARE FOLLOWED.
	2	KNOCK-ON DELTA-RAY HISTORIES ARE NOT FOLLOWED.
IPHOT	1	HISTORIES OF SECONDARY PHOTONS (BREMSSTRAHLUNG, CHARACTERISTIC X-RAYS, ANNIHILATION RADIATION) ARE FOLLOWED.
	2	HISTORIES OF SECONDARY PHOTONS ARE NOT FOLLOWED.
IBAD	1	INTRINSIC EMISSION ANGLE FOR BREMSSTRAHLUNG SAMPLED FROM DETAILED CROSS SECTION TABLES.
	2	INTRINSIC EMISSION ANGLE SAMPLED WITH USE OF SIMPLE APPROXIMATE FORMULA.
IDES	1	HISTORIES OF PHOTON-PRODUCED SECONDARY ELECTRONS ARE FOLLOWED.
	2	THESE HISTORIES ARE NOT FOLLOWED.
ITER		DETERMINES FATE OF ELECTRONS WITH ENERGIES BETWEEN TCUT AND TSAVE.
	1	HISTORY IS CONTINUED ONLY IF ELECTRON CAN REACH A MAJOR BOUNDARY, B.
	2	HISTORY IS CONTINUED ONLY IF ELECTRON CAN REACH AN ENERGY-DEPOSITION SUB-BOUNDARY, BD.
IPSC		CONTROLS THE SCORING OF EMERGENT PHOTON DISTRIBUTIONS AND INTERNAL PHOTON FLUX.
	1	SCORE ALL PHOTONS.
	2	SCORE PRIMARY PHOTONS AND "PHIST DESCENDANTS" (ANNIHILATION QUANTA OR X RAYS RESULTING FROM PHOTON INTERACTIONS WITHOUT CONTROL PASSING FROM SUBROUTINE PHIST).
	3	SCORE BREMSSTRAHLUNG PHOTONS AND "PHIST DESCENDANTS".
	4	SCORE K X-RAYS AND "PHIST DESCENDANTS".
	5	SCORE ANNIHILATION QUANTA AND "PHIST DESCENDANTS".
IPUN	1	SOME RESULTS PUNCHED OUT ON CARDS. IT IS ASSUMED THAT ZTRAN IS SUPPLIED WITH A SUBROUTINE PUNOUT WHICH DETERMINES THE PUNCHING FORMAT AND THE TYPE OF INFORMATION INCLUDED.
	2	NO RESULTS PUNCHED ON CARDS.
ITAPE	1	PROVISION IS MADE FOR WRITING RESULTS ON TAPE (UNIT 11)
	2	NO SPECIAL TAPE WRITTEN.
LMAX		NUMBER OF SLABS MAKING UP COMPOSITE TARGET.
ITMK	1	ENERGY SPACING FOR TMARK GRID LINEAR FROM TIN TO ZERO. THE SMALLEST VALUE OF TMARK = TCUT. THE ENERGY DECREMENT = TIN/JMAX EXCEPT FOR THE LAST BIN. JMAX MAY BE REDUCED FROM ITS ORIGINAL INPUT VALUE DEPENDING ON THE VALUE OF TCUT.
	2	ENERGY SPACING FOR TMARK GRID LINEAR FROM TIN TO TCUT.
	3	ENERGY GRID FOR TMARK LOGARITHMICALLY SPACED FROM TIN TO TCUT.
	4	ENERGY SPACING FOR TMARK GRID READ IN AS TABLE. THE SMALLEST VALUE OF TMARK=TCUT IS INSERTED, AND JMAX MAY BE REDUCED.
JMAX		NUMBER OF ENERGY BINS (DEFINED BY TMARK ARRAY) FOR CLASSIFYING EMERGENT ELECTRONS.
IPMK		SAME SET OF OPTIONS AS FOR ITMK, BUT DEFINED WITH REFERENCE TO PMARK,TPCUT AND JPMAX INSTEAD OF TMARK, TCUT AND JMAX.
JPMAX		NUMBER OF ENERGY BINS (DEFINED BY PMARK ARRAY) FOR CLASSIFYING EMERGENT PHOTONS.
ISMK		SAME SET OF OPTIONS AS FOR ITMK, BUT DEFINED WITH REFERENCE TO SMARK, TCUT (INC=1) OR TPCUT (INC=2) AND JSMAX INSTEAD OF TMARK, TCUT AND JMAX.
JSMAX		NUMBER OF ENERGY BINS (DEFINED BY SMARK ARRAY) FOR CLASSIFYING ABSORBED ENERGY.
IAMK	1	ANGULAR GRID FOR AMARK LINEAR FROM 0 TO 90 DEGREES (ANGLE INCREMEMT = 90/KMAX DEGREES).
	2	ANGULAR GRID FOR AMARK READ IN AS TABLE.
KMAX		NUMBER OF ANGULAR BINS FOR CLASSIFYING THE TRANSMITTED AND REFLECTED ELECTRONS IN REGARD TO THEIR OBLIQUITY WITH RESPECT TO THE NORMAL TO THE TARGET.
IBMK		SAME OPTIONS AS FOR IAMK, BUT DEFINED WITH REFERENCE TO

BMARK AND KPMAX INSTEAD OF AMARK AND KMAX.

KPMAX	NUMBER OF BINS FOR CLASSIFYING THE TRANSMITTED AND REFLECTED PHOTONS IN REGARD TO THEIR OBLIQUITY.
LMIX	INDEX OF LAST SLAB IN WHICH PHOTONS ARE FOLLOWED (USED FOR GENERATING DESCENDANT ELECTRON SOURCES). IF LMIX = 0, LMIX IS SET EQUAL TO LMAX.
IMAX	NUMBER OF HISTORIES OF PRIMARY PARTICLES TO BE GENERATED. THESE PRIMARIES MAY BE EITHER ELECTRONS OR PHOTONS, DEPENDING ON THE VALUE OF THE PARAMETER INC.
LDEP	FOR LDEP GREATER THAN 0, ENERGY AND CHARGE DEPOSITION ARE CALCULATED FOR THE REGION OCCUPIED BY SLABS 1 THROUGH LDEP FOR LDEP LESS THAN 0, ENERGY AND CHARGE DEPOSITION ARE CALCULATED FOR THE REGION OCCUPIED BY THE LDEP-TH SLAB ONLY. FOR LDEP=0, ENERGY AND CHARGE DEPOSITION ARE NOT CALCULATE AND PROGRAM SETS ITER=1.
LZMAX	FOR LZMAX GREATER THAN 0, THE NUMBER OF EQUAL DEPTH-REGIONS INTO WHICH THE ENERGY AND CHARGE DEPOSITION REGION DEFINED BY LDEP IS DIVIDED. FOR LZMAX LESS THAN 0, -LZMAX ENERGY AND CHARGE DEPOSITION DEPTH-REGION BOUNDARIES ARE READ IN.
LEFLUX	SIMILAR TO LDEP, BUT DEFINING THE ELECTRON FLUX SCORING REGION.
LEFMAX	FOR LEFMAX GREATER THAN 0, NUMBER OF EQUAL SUB-REGIONS INTO WHICH THE ELECTRON FLUX REGION, DEFINED BY LEFLUX, IS DIVIDED. FOR LEFMAX LESS THAN 0, -LEFMAX ELECTRON FLUX SUB-REGION BOUNDARIES ARE READ IN. THE DIRECTIONAL FLUX DISTRIBUTIONS ARE RECORDED FOR EACH SUB-REGION.
NCYC	1 OR GREATER. THE BOTTOM ENERGIES OF THE ENERGY CLASSIFICATION BINS FOR THE ELECTRON FLUX ARE EQUAL TO TIN*(2**(-N/NCYC)). TCUT IS ADDED AS THE BOTTOM ENERGY IN THE LIST. -11 OR SMALLER. THE FIRST DIGITS OF THIS NUMBER SUPPLY THE DESIRED NUMBER, JFMAX, OF ENERGY BINS FOR THE ELECTRON FLUX CALCULATION. THE LAST DIGIT ALLOWS FOR ENERGY CLASSIFICATION OPTIONS SIMILAR TO THOSE FOR ITMK.
LPFLUX	SIMILAR TO LDEP, BUT DEFINING THE PHOTON FLUX SCORING REGION.
LPFMAX	SIMILAR TO LEFMAX BUT DETERMINES LPFMAX PHOTON FLUX SUB-REGION BOUNDARIES. FLUX DISTRIBUTIONS OF POSITIVELY AND NEGATIVELY DIRECTED PHOTONS ARE RECORDED FOR EACH SUB-REGION.
NPCYC	SAME OPTIONS AS FOR NCYC, BUT DEFINES ENERGY CLASSIFICATION BINS FOR THE PHOTON FLUX, JPFMAX IN NUMBER. TPCUT IS ADDED AS THE BOTTOM ENERGY.
NFCOS	NUMBER OF EQUAL SOLID ANGLES INTO WHICH FULL SPACE IS DIVIDED FOR THE CLASSIFICATION OF THE ELECTRON DIRECTIONAL FLUX DISTRIBUTIONS.
LBIN	INDEX OF SLAB IN WHICH INITIAL SOURCE IS DEFINED. IF LBIN = 0, LBIN IS SET EQUAL TO 1.
INRAN	INITIAL RANDOM NUMBER (ODD INTEGER).ON IBM 7094 AND UNIVAC 1108 AN OCTAL 12-DIGIT NUMBER WHOSE FIRST DIGIT IS NO GREATER THAN 3. FOR THE IBM 360 SERIES, A DECIMAL INTEGER.
TIN	ENERGY (IN MEV) OF PRIMARY PARTICLES (ELECTRONS OR PHOTONS) INCIDENT ON TARGET. WHEN TIN IS NEGATIVE, INCIDENT SPECTRUM IS NOT MONOENERGETIC, AND PROGRAM EXPECTS INPUT SPECTRUM (JSPEC, SPECIN, ESP).
TCUT	CUT-OFF ENERGY (IN MEV) AT WHICH ELECTRON HISTORIES ARE TERMINATED, A FINAL ADJUSTMENT IS MADE PERTAINING TO THE CALCULATION OF ENERGY AND CHARGE DEPOSITION. THIS ADJUSTMENT IS SIMILAR TO THAT DESCRIBED IN THE COMMENT ON THE PARAMETER TSAVE GIVEN BELOW.
TPCUT	CUT-OFF ENERGY (IN MEV) AT WHICH PHOTON HISTORIES ARE TERMINATED. UPON TERMINATION THE RESIDUAL ENERGY OF THE PHOTON IS ASSUMED TO ESCAPE THE TARGET.
TSAVE	A CUT-OFF ENERGY (IN MEV) GREATER THAN OR EQUAL TO TCUT, WHICH BECOMES OPERATIONAL WHEN THE ELECTRON IS TRAPPED, I.E. WHEN THE RESIDUAL RANGE IS SMALLER THAN THE DISTANCE

	TO THE NEAREST BOUNDARY (SEE ITER). THE HISTORIES OF TRAP ELECTRONS WITH ENERGIES LESS THAN TSAVE ARE TERMINATED. IF SECONDARY ELECTRONS ARE PRODUCED WITH ENERGIES LESS THAN TSAVE AND IN A TRAPPED CONDITION, THEIR HISTORIES ARE NOT FOLLOWED. WHEN HISTORIES ARE EITHER TERMINATED OR NOT FOLLOWED, A FINAL ADJUSTMENT IS MADE FOR THE PURPOSE OF SCORING ENERGY AND CHARGE DEPOSITION. THE ELECTRON IS MADE TO TRAVERSE A FINAL SHORT STRAIGHT PATH IN THE DIRECTION REACHED UPON TERMINATION (OR AT BIRTH IN THE CASE OF SECONDARY ELECTRONS). THE LENGTH OF THE FINAL PATH SEGMENT IS TAKEN TO BE EQUAL TO THE RESIDUAL PRACTICAL RANGE (RESIDUAL MEAN RANGE MULTIPLIED BY A DETOUR FACTOR WHICH IS SUPPLIED AS AN INPUT DATUM), AND THE RESIDUAL ENERGY AND THE CHARGE OF THE ELECTRON ARE ALLOWED TO BE DEPOSITED SOMEWHERE AT RANDOM ALONG THE FINAL PATH SEGMENT. FOR LEFLUX NOT 0 (ELECTRON FLUX DISTRIBUTIONS CALCULATED), THE PROGRAM SETS TSAVE=TCUT, REGARDLESS OF THE INPUT VALUE OF TSAVE.
ANGIN	90.0 OR SMALLER, FOR MONODIRECTIONAL SOURCE. ANGIN IS THE ANGLE (IN DEGREES) OF INCIDENCE WITH RESPECT TO THE NORMAL TO THE TARGET. 100.0 + ANGLE (IN DEGREES), FOR AN ISOTROPIC SOURCE BETWEEN 0 AND ANGLE. 200.0 + ANGLE (IN DEGREES), FOR A COSINE LAW SOURCE BETWEEN 0 AND ANGLE.
ZIN	SOURCE PLANE POSITION, IN G/CM2. IF ZIN = 0, ZIN IS SET EQUAL TO B(LBIN+1). IF ZIN = LBIN = 0, ZIN IS SET EQUAL TO 0 AND LBIN IS SET EQUAL TO 1.
JSPEC	NUMBER OF END POINTS OF THE ENERGY BINS IN THE SPECTRUM OF THE INCIDENT RADIATION. JSPEC, ISAM, SPECIN AND ESP ARE READ IN ONLY WHEN TIN IS NEGATIVE.
ISAM	1 IN SAMPLING FROM THE SOURCE SPECTRUM, INTERPOLATION LINEAR IN ENERGY IS USED. 2 IN SAMPLING FROM THE SOURCE SPECTRUM, INTERPOLATION LOGARITHMIC IN ENERGY IS USED. 3 SOURCE SPECTRUM IS SAMPLED FROM A SET OF DISCRETE ENERGIES.
SPECIN	FOR ISAM=1 AND 2, CUMULATIVE PROBABILITY DISTRIBUTION FOR THE SPECTRUM OF INCIDENT RADIATION. SPECIN(1)=1.0 AND SPECIN(JSPEC)=0.0. FOR ISAM=3, RELATIVE PROBABILITIES OF THE DISCRETE LINES COMPRISING THE INCIDENT SPECTRUM. THESE PROBABILITIES ARE ALTERED SLIGHTLY BY THE PROGRAM SO THAT INTEGRAL NUMBERS OF HISTORIES ARE CALCULATED FOR EACH LINE. THE NUMBERS OF HISTORIES AND THE ALTERED RELATIVE PROBABILITIES ARE PRINTED OUT FOR REFERENCE.
ESP	ENERGIES (IN MEV) IN DESCENDING ORDER ASSOCIATED WITH THE DISTRIBUTION SPECIN.
BNUM	NOMINAL NUMBER OF BREMSSTRAHLUNG PHOTONS (WITH ENERGIES GREATER THAN TPCUT) THAT ONE WANTS TO SAMPLE PER ELECTRON HISTORY. USING THE BREMSSTRAHLUNG CROSS SECTION AND ASSUMING THE CONTINUOUS SLOWING-DOWN APPROXIMATION FOR THE ELECTRON ENERGY LOSS BETWEEN TIN AND TCUT, THE PROGRAM CALCULATES A FACTOR CALLED SCALE. THE BREMSSTRAHLUNG CROSS SECTIONS ARE THEN MULTIPLIED BY SCALE, AND THE SAMPLED PHOTONS ARE GIVEN THE STATISTICAL WEIGHT 1.0/SCALE. THIS ADJUSTMENT IS MADE ON THE BASIS OF PRODUCTION PROBABILITIES PERTAINING ONLY TO THE MATERIAL OF THE FIRST SLAB AND DOES NOT TAKE INTO ACCOUNT PASSAGE OF THE ELECTRONS INTO SUBSEQUENT SLABS. DUE TO THIS EFFECT, THE OCCURRENCE OF ENERGY-LOSS STRAGGLING, AND THE ESCAPE OF ELECTRONS FROM THE TARGET, THE ACTUAL NUMBER OF PHOTONS SAMPLED IN A RUN WILL DIFFER SOMEWHAT FROM THE EXPECTED NOMINAL NUMBER. THE PROGRAM DOES NOT ALLOW SCALE TO HAVE A VALUE SMALLER THAN 1.0. THE VALUE SCALE = 1.0 CAN BE OBTAINED BY SETTING BNUM=0.0.
XNUM	PARAMETER ANALOGOUS TO BNUM, BUT FOR K-SHELL IONIZATION BY ELECTRON IMPACT. THE NOMINAL NUMBER OF EMITTED K X-RAYS WILL BE WK*XNUM.
DLIM	PROBABILITY OF FOLLOWING THE HISTORY OF A SECONDARY

	ELECTRON PRODUCED BY A PHOTON. IF THE ENERGY OF THE NEWLY BORN ELECTRON IS GREATER THAN TSAVE, OR IF IT IS BETWEEN TCUT AND TSAVE AND THE RESIDUAL RANGE IS LONG ENOUGH FOR THE NEAREST BOUNDARY TO BE REACHED (SEE ITER), THE HISTORY IS FOLLOWED WITH PROBABILITY DLIM. THE STATISTICAL WEIGHT ASSOCIATED WITH THE HISTORY IS MULTIPLIED BY 1.0/DLIM. REGARDLESS OF THE INPUT VALUE OF DLIM, THE PROGRAM ADJUSTS ITS VALUE, IF NECESSARY, SO THAT DLIM IS GREATER THAN 1.0/SCALE. THE VALUE DLIM=1.0/SCALE CAN BE OBTAINED BY SETTING DLIM=0.0.
B	THICKNESSES OF SLABS DEFINING TARGET, IN G/CM**2 AND IN ASCENDING ORDER.
MATNO	INDICES SPECIFYING WHICH OF THE MSET CROSS-SECTION DATA SETS PERTAIN TO THE SLABS B. THE NUMBERING CORRESPONDS TO THE ORDER IN WHICH THESE DATA SETS WERE READ.
LESPEC(L)	PERTAINS TO JOINT ANGULAR AND ENERGY DISTRIBUTION OF ELECTRONS EMERGING FROM L'TH TARGET SLAB. 0 NO DISTRIBUTION CALCULATED. 1 DISTRIBUTION CALCULATED FOR TRANSMITTED ELECTRONS. 2 DISTRIBUTION CALCULATED FOR REFLECTED ELECTRONS. 3 DISTRIBUTION CALCULATED FOR TRANSMITTED AND REFLECTED ELECTRONS.
LPSPEC(L)	SIMILAR TO LESPEC(L), BUT PERTAINS TO JOINT ANGULAR AND ENERGY DISTRIBUTION OF PHOTONS EMERGING FROM L'TH TARGET SLAB.
TMARK	BOTTOM ENERGY (MEV, DESCENDING ORDER) OF ENERGY BINS FOR CLASSIFYING SPECTRA OF TRANSMITTED AND REFLECTED ELECTRONS. READ IN AS TABLE ONLY WHEN ITMK=4.
PMARK	BOTTOM ENERGY (MEV, DESCENDING ORDER) OF ENERGY BINS FOR CLASSIFYING SPECTRA OF TRANSMITTED AND REFLECTED PHOTONS. READ IN AS TABLE ONLY WHEN IPMK=4.
SMARK	BOTTOM ENERGY (MEV, DESCENDING ORDER) OF ENERGY BINS THAT ARE THE COMPLIMENT OF THOSE USED TO CLASSIFY ABSORBED ENERGY (I.E., TIN OR ESP(1) MINUS SMARK(J)). READ IN AS TABLE ONLY WHEN ISMK=4.
AMARK	TOP OF ELECTRON OBLIQUITY BINS (IN DEGREES), IN ASCENDING ORDER TO 90 DEGREES. TO BE READ IN AS TABLE ONLY WHEN IAMK=2.
BMARK	TOP OF PHOTON OBLIQUITY BINS (IN DEGREES), IN ASCENDING ORDER TO 90 DEGREES. TO BE READ IN AS TABLE ONLY WHEN IBMK=2.
BD	ENERGY AND CHARGE DEPOSITION SUB-REGION BOUNDARIES (IN ASCENDING ORDER) IN G/CM**2 (FOR IUNT=2). TO BE READ IN AS TABLE ONLY WHEN LZMAX IS LESS THAN 0.
BF	ELECTRON FLUX SUB-REGION BOUNDARIES (IN ASCENDING ORDER) IN G/CM**2 (FOR IUNT=2). TO BE READ IN AS TABLE ONLY WHEN LEFMAX IS LESS THAN 0.
FMARK	BOTTOM ENERGY (MEV, DESCENDING ORDER) OF ENERGY BINS FOR CLASSIFYING ELECTRON FLUX SPECTRA. READ IN AS TABLE ONLY FOR NCYC LESS THAN 0 WITH LAST DIGIT EQUAL TO 4.
BPF	PHOTON FLUX SUB-REGION BOUNDARIES (IN ASCENDING ORDER) IN G/CM**2 (FOR IUNT=2). TO BE READ IN ONLY WHEN LPFMAX IS LESS THAN 0.
FPMARK	BOTTOM ENERGY (MEV, DESCENDING ORDER) OF ENERGY BINS FOR CLASSIFYING PHOTON FLUX SPECTRA. READ IN AS TABLE ONLY FOR NPCYC LESS THAN 0 WITH LAST DIGIT EQUAL TO 4.

BRIEF DESCRIPTION OF SUBROUTINES USED IN PROGRAM ZTRAN 4C

SUBROUTINE RANDA
GENERATES PSEUDO-RANDOM NUMBERS.

SUBROUTINE QPOL
PERFORMS PARABOLIC INTERPOLATION.

SUBROUTINE CLASS
FROM ELECTRON ENERGY, CALCULATES INDEX REQUIRED FOR TABLE LOOK-UP OR EVALUATION OF QUANTITIES DEPENDING ON ELECTRON ENERGY.

SUBROUTINE CROSS
CALCULATES ENERGY INDEX REQUIRED FOR TABLE LOOK-UP OF PHOTON CROSS SECTIONS.

SUBROUTINE XINPUT
READS INTO MEMORY VARIOUS CROSS SECTIONS AND MULTIPLE SCATTERING DISTRIBUTIONS. INPUT COMES FROM CARDS AND FROM DATAPAC TAPE.

SUBROUTINE XPREP
PROCESSES INPUT DATA TO FACILITATE QUICK AND EASY TABLE LOOK-UP.

SUBROUTINE PTAB
PREPARES TABLES OF PHOTON CROSS SECTIONS NEEDED FOR TABLE LOOK-UPS.

SUBROUTINE INPUT
READS INTO MEMORY THE VARIOUS RUN PARAMETERS.

SUBROUTINE START
COMPUTES INITIAL ELECTRON RANGE. CHECKS CONSISTENCY OF VARIOUS RUN PARAMETERS AND HALTS RUNNING OF PROGRAM IF INCONSISTENCIES ARE DISCOVERED.

SUBROUTINE FLIST
GENERATES, OR READS IN AS INPUT, ENERGY LISTS REQUIRED FOR CLASSIFYING ELECTRON AND PHOTON FLUX DATA.

SUBROUTINE ELIST
GENERATES, OR READS IN AS INPUT, ENERGY LISTS REQUIRED FOR CLASSIFYING ELECTRON AND PHOTON OUTPUT DATA.

SUBROUTINE ALIST
GENERATES, OR READS AS INPUT, ANGLE LISTS REQUIRED FOR CLASSIFYING ELECTRON AND PHOTON OUTPUT DATA.

SUBROUTINE PREP
DERIVES FROM RUN PARAMETERS AND CROSS SECTION DATA VARIOUS ADDITIONAL AUXILIARY TABLES AND PARAMETERS. ALSO CLEARS OUTPUT STORAGE ARRAYS.

SUBROUTINE SECP
CALCULATES AUXILIARY TABLES PERTAINING TO THE PRODUCTION OF ENERGETIC KNOCK-ON ELECTRONS.

SUBROUTNE CLASSP
FROM PHOTON ENERGY, CALCULATES INDEX REQUIRED FOR TABLE LOOK-UP OR EVALUATION OF QUANTITIES DEPENDING ON ELECTRON ENERGY.

SUBROUTINE CRISS
COMPUTES PARAMETERS NEEDED FOR SPEEDING UP TABLE LOOK-UP IN SUBROUTINE CROSS

SUBROUTINE HIST
SETS UP INITIAL CONDITIONS FOR PRIMARY AND SECONDARY ELECTRONS IN CASE OF AN ELECTRON-INITIATED CASCADE, OR FOR PRIMARY PHOTONS AND SECONDARY ELECTRONS IN CASE OF A PHOTON-INITIATED CASCADE. CALLS THE VARIOUS ROUTINES REQUIRED FOR THE GENERATION OF PRIMARY AND SECONDARY ELECTRON HISTORIES. KEEPS TRACK OF THE TOTAL ENERGY DEPOSITED IN THE TARGET BY THE PARTICLE INITIATING THE CASCADE AND ALL ITS DESCENDANTS.

SUBROUTINE EHIST

GENERATES A SINGLE ELECTRON HISTORY (PRIMARY OR SECONDARY) AND CALLS THE SUBROUTINES REQUIRED TO CALCULATE THE DESIRED OUTPUT INFORMATION (TRANSMISSION, REFLECTION, ENERGY AND CHARGE DEPOSITON, FLUX).

SUBROUTINE LOSS

SAMPLES ELECTRON ENERGY LOSS FROM LANDAU DISTRIBUTION (WITH BLUNCK-LEISEGANG CORRECTION).

SUBROUTINE MULT

SAMPLES ANGULAR DEFLECTION DUE TO MULTIPLE ELASTIC SCATTERING FROM GOUDSMIT-SAUNDERSON DISTRIBUTION.

SUBROUTINE KNOCK

SAMPLES INITIAL ENERGY AND DIRECTION OF KNOCK-ON ELECTRON ACCORDING TO MOLLER CROSS SECTION. IF THE HISTORY OF THE SECONDARY PARTICLE IS NOT TO BE FOLLOWED, DISPOSES OF THE RESIDUAL ENERGY FOR THE PURPOSE OF SCORING ENERGY DEPOSITION.

SUBROUTINE BREMS

CASE A (BNUM=0.0, BREMSSTRAHLUNG PHOTONS SAMPLED IN ACCORDANCE WITH NATURAL OCCURRENCE). SAMPLES NUMBER OF PHOTONS PRODUCED IN STEP FROM POISSON DISTRIBUTION WITH MEAN GIVEN BY BREMSSTRAHLUNG CROSS SECTION. SCORES INTERNAL BREMSSTRAHLUNG EFFICIENCY, SUPPLIES BREMSSTRAHLUNG ENERGY LOSS FOR SUBROUTINE EHIST, SAMPLES INITIAL DIRECTIONS, ENERGIES AND POSITIONS FOR BREMSSTRAHLUNG PHOTONS. IF THE SECONDARY PHOTON HISTORIES ARE TO BE FOLLOWED, CALLS REQUIRED SUBROUTINES TO ACCOMPLISH THIS.

CASE B (BNUM GREATER THAN 0, ARTIFICIALLY INCREASED NUMBER OF PHOTONS SAMPLED). AS IN CASE A, SUPPLIES BREMSSTRAHLUNG ENERGY LOSS FOR SUBROUTINE EHIST. GENERATES INITIAL CONDITIONS FOR SCALE TIMES THE MEAN NUMBER OF BREMSSTRAHLUNG PHOTONS WITH ENERGIES ABOVE TPCUT. THESE PHOTONS ARE SUPPLIED WITH APPROPRIATE STATISTICAL WEIGHTS AND FOLLOWED IN ORDER TO OBTAIN INFORMATION ABOUT THE INTERNAL BREMSSTRAHLUNG EFFICIENCY, THICK-TARGET BREMSSTRAHLUNG AND THE SECONDARY ELECTRONS PRODUCED BY THE BREMSSTRAHLUNG.

SUBROUTINE PHOTS

SAMPLES ENERGY OF PHOTON GENERATED IN BREMSSTRAHLUNG EVENT.

SUBROUTINE PINT

SCORES INTERNAL BREMSSTRAHLUNG EFFICIENCY AND CALLS SUBROUTINE PHIST FOR THE GENERATION OF PHOTON TRAJECTORIES.

SUBROUTINE KXRAY

SIMILAR IN ITS TASKS TO SUBROUTINE BREMS, BUT PERTAINS TO EMISSION OF K X-RAYS DUE TO ELECTRON-IMPACT IONIZATION RATHER THAN TO BREMSSTRAHLUNG PHOTONS FROM THE CONTINUOUS SPECTRUM.

SUBROUTINE PSTART

SAMPLES POSITION WHERE SECONDARY PHOTONS ARE BORN AND ESTIMATES ELECTRON DIRECTION AT THAT POINT. REJECTS PHOTONS BORN OUTSIDE THE MEDIUM.

SUBROUTINE ESCORE

SCORES DATA PERTINENT TO THE TRANSMISSION AND REFLECTION OF ELECTRONS.

SUBROUTINE ANGLE

SAMPLES ANGULAR MULTIPLE SCATTERING DEFLECTION FROM EXPONENTIAL APPROXIMATION TO GOUDSMIT-SAUNDERSON DISTRIBUTION, TO BE USED IN PARTIAL SUBSTEPS TO A BOUNDARY.

SUBROUTINE SPILL

SCORES ENERGY DEPOSITION BY ELECTRONS IN THE DEFINED ENERGY DEPOSITION SUB-REGIONS.

SUBROUTINE RAID

SIMILAR TO SPILL, BUT SCORES CHARGE DEPOSITION.

SUBROUTINE FORN
SCORES DIRECTIONAL FLUX SPECTRUM OF ELECTRONS IN THE DEFINED ELECTRON FLUX SUB-REGIONS.

SUBROUTINE PHIST
MAIN ROUTINE FOR SCORING PHOTON HISTORIES. TAKES INTO ACCOUNT PHOTOELECTRIC ABSORPTION, COMPTON SCATTERING AND PAIR PRODUCTION, AS WELL AS THE SECONDARY ELECTRONS AND PHOTONS RESULTING FROM THESE EVENTS. THE INITIAL CONDITIONS FOR SECONDARY ELECTRONS ARE EXAMINED BY SUBROUTINE SAVE TO DETERMINE WHETHER THEIR HISTORIES SHOULD BE FOLLOWED AT ALL. IF THE ANSWER IS YES, THE INITIAL CONDITIONS ARE STORED FOR LATER USE BY SUBROUTINE HIST, BUT ONLY IN A FRACTION DLIM OF ALL CASES. IF THE ANSWER IS NO, THE CHARGE AND RESIDUAL PARTICLE ENERGY ARE TAKEN INTO ACCOUNT FOR THE PURPOSE OF SCORING ENERGY AND CHARGE DEPOSITION. THE POSSIBILITY OF THE EMISSION OF PAIR ANNIHILATION AT THE END OF A POSITRON TRACK IS ALSO TAKEN INTO ACCOUNT, AND THE RESULTING PHOTONS ARE FOLLOWED IN SUBROUTINE PHIST. IN THE PRESENT VERSION, THE POSSIBILITY OF ANNIHILATION IN FLIGHT IS DISREGARDED. IF FLUORESCENCE PHOTONS ARE PRODUCED AFTER A PHOTOELECTRIC ABSORPTION EVENT, THEIR HISTORIES ARE ALSO FOLLOWED IN SUBROUTINE PHIST.

SUBROUTINE PATH
DETERMINES PATHLENGTH THROUGH MULTI-LAYERED TARGET TO NEXT PHOTON INTERACTION. SIGNALS END OF PHOTON HISTORY DUE TO ESCAPE.

SUBROUTINE PSCORE
SCORES PHOTON TRANSMISSION AND REFLECTION WITH THE USE OF AN WEIGHT FACTOR EQUAL TO THE PROBABILITY THAT THE PHOTON, SUBSEQUENT TO THE COLLISION UNDER CONSIDERATION, WILL REACH THE BOUNDARY OF INTEREST WITHOUT FURTHER INTERACTION IN THE MEDIUM. FOR THE SCORING OF ABSORBED SPECTRA, HOWEVER, THE PHOTON HISTORY MUST CROSS A BOUNDARY TO COUNT AS EMERGENT ENERGY.

SUBROUTINE PORN
SCORES FLUX SPECTRUM OF POSITIVELY AND NEGATIVELY DIRECTED PHOTONS IN THE DEFINED PHOTON FLUX SUB-REGIONS.

SUBROUTINE BANGLE
SAMPLES THE INTRINSIC BREMSSTRAHLUNG PHOTON EMISSION ANGLE (WITH RESPECT TO THE DIRECTION OF THE ELECTRON) FROM TABULATED DISTRIBUTION (DERIVED FROM BETHE-HEITLER THEORY CROSS SECTIONS).

SUBROUTINE LANGLE
SIMILAR TO BANGLE, BUT USES SIMPLE APPROXIMATION TO BETHE-HEITLER CROSS SECTION. IS ALSO USED TO SAMPLE THE INTRINSIC EMISSION ANGLE FOR PAIR ELECTONS (WITH RESPECT TO THE PHOTON DIRECTION).

SUBROUTINE RANGLE
COMPUTES RANDOM DIRECTION COSINE DISTRIBUTED UNIFORMLY BETWEEN -1 AND +1.

SUBROUTINE PEAL
SAMPLES DIRECTION OF PHOTO-ELECTRON FROM TABULATED DISTRIBUTIONS (BASED ON SAUTER CROSS SECTION AT HIGH ENERGIES AND ON FISCHER CROSS SECTION AT LOW ENERGIES).

SUBROUTINE SPLIT
SAMPLES ENERGY OF PAIR ELECTRON FROM TABULATED DISTRIBUTIONS (BASED ON HOUGH CROSS SECTION).

SUBROUTINE SCATT
SAMPLES ENERGY OF COMPTON RECOIL ELECTRON FROM KLEIN-NISHINA DISTRIBUTION, AND COMPUTES CORRESPONDING ANGULAR DEFLECTION OF THE PHOTON.

SUBROUTINE FOLD
COMPOUNDS INITIAL OBLIQUITY WITH SAMPLED DEFLECTION TO GIVE FINAL OBLIQUITY IN FIXED COORDINATE SYSTEM.

SUBROUTINE SAVE
MAKES THE DECISION WHETHER A HISTORY SHOULD BE CONTINUED, AND WHETHER THE INITIAL CONDITIONS FOR A NEW HISTORY SHOULD BE SAVED FOR LATER USE. HISTORIES ARE CONTINUED OR SAVED WHEN THE ELECTRON ENERGY IS GREATER THAN TSAVE, OR WHEN THE ENERGY IS SMALLER THAN TSAVE BUT GREATER THAN TCUT AND THE RESIDUAL RANGE IS LONG ENOUGH FOR THE ELECTRON TO REACH THE NEAREST BOUNDARY.

SUBROUTINE STORE
STORES INITIAL CONDITIONS OF SECONDARY ELECTRONS FOR LATER USE BY SUBROUTINE HIST. IF SECONDARY STORAGE IS EXCEEDED, THE SUBROUTINE HALTS THE MAIN PROGRAM.

SUBROUTINE KICK
THE ELECTRON IS MADE TO TRAVERSE A FINAL SHORT PATH SEGMENT IN THE FINAL DIRECTION REACHED. THE LENGTH OF THE FINAL PATH SEGMENT IS TAKEN TO BE THE RESIDUAL PRACTICAL RANGE (RESIDUAL MEAN RANGE MULTIPLIED BY A SUITABLE DETOUR FACTOR THAT IS TAKEN FROM TRANSPORT CALCULATIONS OR EXPERIMENTS).

BLOCK DATA
DEFINES PRINTING FORMATS FOR THE OUTPUT PORTION OF ZTRAN.

SUBROUTINE OUTPUT
DRIVES THE OUTPUT ROUTINES OF ZTRAN.

SUBROUTINE NORM
NORMALIZES OUTPUT DATA. ALSO PRINTS A PORTION OF THE DATA.

SUBROUTINE PRTOUT
PRINTS DATA. DETAILED HEADINGS ARE PROVIDED SO THAT THE OUTPUT SHOULD BE SELF-EXPLANATORY.

SUBROUTINE TAPOUT
PROVIDES FOR WRITING OUTPUT DATA ONTO TAPE (UNIT 11).

SUBROUTINE PUNOUT
GENERAL NAME FOR A SUBROUTINE THAT PUNCHES OUT A DESIRED SUBSET OF THE DATA PRODUCED. SPECIAL VERSIONS OF THE SUBROUTINE HAVE TO BE WRITTEN AS THE NEED ARISES. THESE DATA CAN BE WRITTEN ONTO TAPE OR OTHER DATA STORAGE DEVICES BY REDEFINING THE PUNCH UNIT (UNIT 7) APPROPRIATELY.

APPENDIX B

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 MSET
    4

NUMBER OF SETS ON DATAPAC TAPE =  41

MATERIAL NUMBER 1

 NSET  NTAB  NEDG
   16     2     1

MPAIR  MTAX
   25    41     2

GAMMA RAY CROSS SECTION DATA

ENERGIES (MEV)
1000.000000  800.000000  600.000000  500.000000  400.000000  300.000000
 200.000000  150.000000  100.000000   80.000000   60.000000   50.000000
  40.000000   30.000000   20.000000   15.000000   10.000000    8.000000
   6.000000    5.000000    4.000000    3.000000    2.000000    1.500000
   1.000000    0.800000    0.600000    0.500000    0.400000    0.300000
   0.200000    0.150000    0.100000    0.080000    0.060000    0.050000
   0.040000    0.030000    0.020000    0.015000    0.010000
   0.010000    0.001000

TOTAL ATTENUATION COEFFICIENTS (CM2/G)
   0.045400    0.045100    0.044200    0.043900    0.043200    0.042200
   0.040600    0.039200    0.037000    0.035800    0.034100    0.033000
   0.031700    0.030100    0.028400    0.027600    0.027100    0.027500
   0.028600    0.029800    0.031800    0.035000    0.041600    0.047700
   0.058700    0.065300    0.074500    0.080900    0.089400    0.102000
   0.126000    0.156000    0.249000    0.368000    0.699000    1.110000
   2.060000    4.700000   15.500000   35.899994  112.000000
 112.000000  112.000000

RATIO OF SCATTERING PLUS PAIR PRODUCTION TO TOTAL ATTENUATION COEFFICIENTS
   1.000000    1.000000    1.000000    1.000000    1.000000    1.000000
   1.000000    1.000000    1.000000    1.000000    1.000000    1.000000
   1.000000    1.000000    1.000000    1.000000    0.999742    0.999674
   0.999557    0.999464    0.999339    0.999108    0.998630    0.998100
   0.996680    0.995190    0.991740    0.987900    0.979800    0.959900
   0.890000    0.788000    0.546000    0.389000    0.216000    0.140000
   0.077300    0.035000    0.011100    0.004840    0.001580
   0.001580    0.001580

RATIO OF SCATTERING TO SCATTERING PLUS PAIR PRODUCTION ATTENUATION COEFFICIENTS
   0.007110    0.008710    0.011400    0.013400    0.016400    0.021500
   0.031400    0.041500    0.061900    0.077100    0.103000    0.123000
   0.153000    0.203000    0.295000    0.379000    0.522000    0.604000
   0.709000    0.771000    0.839000    0.909700    0.972900    0.993990
   1.000000

IONIZATION DATA FOR SHELL 1

BINDING ENERGY (MEV), PHOTOEFFECT EFFICIENCY AND FLUORESCENT EFFICIENCY
   0.004964    0.900900    0.170000

 NUMK  NUMA
    4     3

X-RAY ENERGIES (MEV)
   0.004510    0.004504    0.004931    0.004964

X-RAY ACCUMULATED RELATIVE INTENSITIES
   0.587000    0.889000    0.995000    1.000000

AUGER ELECTRON ENERGIES (MEV)
   0.004002    0.004483    0.004964

AUGER ELECTRON ACCUMULATED RELATIVE INTENSITIES
   0.806000    1.000000    1.000000

     DETOUR  EXCI1(KEV)  AVGKE(KEV)
   0.620000    0.000000    0.000000

INPUT FROM DATAPAC

DATAPAC-6B, SET 16 - TI, 64-0.001, 8/5.                       19 APR 84.
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 NSET  ITRM  IZIP  ISGN  ISUB  INAL  ICYC  NCYC  NMAX       EMAX           EMIN           RMAX       LMAT
   16     5     0     1     5     1     1     8   128  6.4000000E+01  9.7656250E-04  2.2409225E+01     1

DATAPREP DATA FOR DATAPAC SET  16   128    33     5   121  2.240923E+01

COLLISION / TOTAL DE/DX RATIOS FOR DATAPAC SET  16

CUMULATIVE BREMSSTRAHLUNG CROSS SECTIONS FOR DATAPAC SET  16

CUMULATIVE BREMSSTRAHLUNG ANGULAR DISTRIBUTIONS FOR DATAPAC SET  16

LANGAUSS - EQUIPROBABLE ENDPOINTS FOR INTERPOLATION

K X-RAY PRODUCTION FOR DATAPAC SET  16

PHOTOELECTRON ANGULAR DISTRIBUTIONS

PAIR ELECTRON ENERGY DIVISION DISTRIBUTION (LEAD)

MATERIAL NUMBER 2

 NSET  NTAB  NEDG
   25     6     1

MPAIR  MTAX
   25    33     8     2     3     3     2

GAMMA RAY CROSS SECTION DATA

ENERGIES (MEV)
1000.000000  800.000000  600.000000  500.000000  400.000000  300.000000
 200.000000  150.000000  100.000000   80.000000   60.000000   50.000000
  40.000000   30.000000   20.000000   15.000000   10.000000    8.000000
   6.000000    5.000000    4.000000    3.000000    2.000000    1.500000
   1.000000    0.800000    0.600000    0.500000    0.400000    0.300000
   0.200000    0.150000    0.115591
   0.115591    0.100000    0.080000    0.060000    0.050000    0.040000
   0.030000    0.021800
   0.021800    0.020900
   0.020900    0.020000    0.017200
   0.017200    0.015000    0.010000
   0.010000    0.001000

TOTAL ATTENUATION COEFFICIENTS (CM2/G)
   0.123000    0.122000    0.121000    0.191000    0.117000    0.115000
   0.110000    0.106000    0.098400    0.094800    0.088900    0.085000
   0.079900    0.073300    0.063600    0.057300    0.050600    0.047900
   0.045400    0.044400    0.043400    0.043500    0.047000    0.053900
   0.075400    0.096400    0.140000    0.185000    0.273000    0.485000
   1.230000    2.470000    4.710000
   1.190000    1.710000    3.040000    6.450000   10.400000   18.699997
  39.600006   89.500000
  77.500000   85.600006
  60.300003   68.500000  103.000000
  42.800003   60.300003  173.000000
 173.000000  173.000000

RATIO OF SCATTERING PLUS PAIR PRODUCTION TO TOTAL ATTENUATION COEFFICIENTS
   1.000000    1.000000    1.000000    1.000000    1.000000    1.000000
   1.000000    1.000000    0.999383    0.999200    0.998860    0.998510
   0.998040    0.997070    0.994780    0.992070    0.985600    0.980200
   0.969800    0.959900    0.944000    0.913400    0.847000    0.778000
   0.651000    0.567000    0.446000    0.364000    0.269000    0.169000
   0.077100    0.041800    0.023500
   0.093200    0.066900    0.039700    0.019700    0.012500    0.007190
   0.003530    0.001600
   0.001850    0.001680
   0.002380    0.002100    0.001410
   0.003400    0.002430    0.008610
   0.008610    0.008610

RATIO OF SCATTERING TO SCATTERING PLUS PAIR PRODUCTION ATTENUATION COEFFICIENTS
   0.002200    0.002710    0.003500    0.004140    0.005080    0.006650
   0.009810    0.013000    0.019600    0.024500    0.033000    0.040300
   0.051400    0.070600    0.112000    0.155000    0.239000    0.297000
   0.388000    0.454000    0.547000    0.675000    0.857000    0.953000
   1.000000

IONIZATION DATA FOR SHELL  1
```

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BINDING ENERGY (MEV), PHOTOEFFECT EFFICIENCY AND FLUORESCENT EFFICIENCY
   0.115591    0.766000    0.963000

 NUMK  NUMA
    4     3

X-RAY ENERGIES (MEV)
   0.098428    0.094648    0.111289    0.114549

X-RAY ACCUMULATED RELATIVE INTENSITIES
   0.478000    0.748000    0.934000    1.000000

AUGER ELECTRON ENERGIES (MEV)
   0.075685    0.095638    0.115591

AUGER ELECTRON ACCUMULATED RELATIVE INTENSITIES
   0.567000    0.970000    1.000000

     DETOUR  EXCI1(KEV)  AVGKE(KEV)
   0.290000    0.000000    0.000000

INPUT FROM DATAPAC

DATAPAC-6B, SET 25 -  U, 64-0.001, 8/20.                     19 APR 84.

 NSET  ITRM  IZIP  ISGN  ISUB  INAL  ICYC  NCYC  NMAX      EMAX           EMIN           RMAX       LMAT
   25     5     0     1    20     1     1     8   128  6.4000000E+01  9.7656250E-04  1.5835600E+01     1

DATAPREP DATA FOR DATAPAC SET  25   128    33    20   121  1.583560E+01

COLLISION / TOTAL DE/DX RATIOS FOR DATAPAC SET  25

CUMULATIVE BREMSSTRAHLUNG CROSS SECTIONS FOR DATAPAC SET  25

CUMULATIVE BREMSSTRAHLUNG ANGULAR DISTRIBUTIONS FOR DATAPAC SET  25

LANGAUSS - EQUIPROBABLE ENDPOINTS FOR INTERPOLATION

K X-RAY PRODUCTION FOR DATAPAC SET  25

PHOTOELECTRON ANGULAR DISTRIBUTIONS

PAIR ELECTRON ENERGY DIVISION DISTRIBUTION (LEAD)

MATERIAL NUMBER 3

 NSET  NTAB  NEDG
   26     2     1

MPAIR  MTAX
   25    46     5

GAMMA RAY CROSS SECTION DATA

ENERGIES (MEV)
1000.000000  800.000000  600.000000  500.000000  400.000000  300.000000
 200.000000  150.000000  100.000000   80.000000   60.000000   50.000000
  40.000000   30.000000   20.000000   15.000000   10.000000    8.000000
   6.000000    5.000000    4.000000    3.000000    2.000000    1.500000
   1.000000    0.800000    0.600000    0.500000    0.400000    0.300000
   0.200000    0.150000    0.100000    0.080000    0.060000    0.050000
   0.040000    0.030000    0.020000    0.015000    0.010000    0.008000
   0.006000    0.005000    0.004000    0.003203
   0.003203    0.003000    0.002000    0.001500    0.001000

TOTAL ATTENUATION COEFFICIENTS (CM2/G)
   0.019890    0.019690    0.019400    0.019180    0.018900    0.018490
   0.017870    0.017420    0.016850    0.016500    0.016210    0.016100
   0.016060    0.016240    0.017020    0.018070    0.020430    0.022250
   0.025240    0.027530    0.030800    0.035810    0.044460    0.051760
   0.063560    0.070700    0.080460    0.086990    0.095260    0.106400
   0.122600    0.134200    0.151100    0.161600    0.179200    0.195800
   0.229200    0.318300    0.691100    1.455000    4.820000    9.320000
  23.000000   39.800003   77.100006  149.000000
 133.000000  161.000000  524.000000 1185.000000 3584.000000

RATIO OF SCATTERING PLUS PAIR PRODUCTION TO TOTAL ATTENUATION COEFFICIENTS
   1.000000    1.000000    1.000000    1.000000    1.000000    1.000000
   1.000000    1.000000    1.000000    1.000000    1.000000    1.000000
   1.000000    1.000000    1.000000    1.000000    1.000000    1.000000
   1.000000    1.000000    1.000000    1.000000    1.000000    1.000000
   1.000000    0.999900    0.999900    0.999800    0.999600    0.999100
   0.996700    0.994000    0.980100    0.962300    0.915200    0.862100
   0.759200    0.564200    0.268800    0.130000    0.039940    0.013000
   0.004570    0.002330    0.001010    0.000411
   0.000461    0.000355    0.000064    0.000018    0.000003

RATIO OF SCATTERING TO SCATTERING PLUS PAIR PRODUCTION ATTENUATION COEFFICIENTS
   0.017660    0.021680    0.028180    0.033280    0.040790    0.053260
   0.077730    0.101700    0.151200    0.181600    0.234500    0.274000
   0.329000    0.409400    0.536700    0.629800    0.752800    0.811700
   0.874800    0.907400    0.939000    0.968200    0.991200    0.998100
   1.000000

IONIZATION DATA FOR SHELL  1

BINDING ENERGY (MEV), PHOTOEFFECT EFFICIENCY AND FLUORESCENT EFFICIENCY
   0.003203    0.107000    0.115000

 NUMK  NUMA
    2     2

X-RAY ENERGIES (MEV)
   0.002957    0.003191

X-RAY ACCUMULATED RELATIVE INTENSITIES
   0.935000    1.000000

AUGER ELECTRON ENERGIES (MEV)
   0.002710    0.002936

AUGER ELECTRON ACCUMULATED RELATIVE INTENSITIES
   0.883000    1.000000

     DETOUR   EXCI1(KEV)  AVGKE(KEV)
   0.840000    0.000000    0.000000

INPUT FROM DATAPAC

DATAPAC-6B, SET 26 - AIR, 64-0.001 MEV, 8/2.                 19 APR 84.

 NSET  ITRM  IZIP  ISGN  ISUB  INAL  ICYC  NCYC  NMAX       EMAX            EMIN            RMAX        LMAT
   26     5     0     1     2     1     1     8   128  6.4000000E+01  9.7656250E-04  2.3319153E+01     4

DATAPREP DATA FOR DATAPAC SET  26   128    33     2   121  2.331915E+01

COLLISION / TOTAL DE/DX RATIOS FOR DATAPAC SET  26

CUMULATIVE BREMSSTRAHLUNG CROSS SECTIONS FOR DATAPAC SET  26

CUMULATIVE BREMSSTRAHLUNG ANGULAR DISTRIBUTIONS FOR DATAPAC SET  26

LANGAUSS - EQUIPROBABLE ENDPOINTS FOR INTERPOLATION

K X-RAY PRODUCTION FOR DATAPAC SET  26

PHOTOELECTRON ANGULAR DISTRIBUTIONS

PAIR ELECTRON ENERGY DIVISION DISTRIBUTION (LEAD)

MATERIAL NUMBER 4

 NSET  NTAB  NEDG
   35     2     1

MPAIR  MTAX
   25    41     2

GAMMA RAY CROSS SECTION DATA

ENERGIES (MEV)
1000.000000  800.000000  600.000000  500.000000  400.000000  300.000000
 200.000000  150.000000  100.000000   80.000000   60.000000   50.000000
  40.000000   30.000000   20.000000   15.000000   10.000000    8.000000
   6.000000    5.000000    4.000000    3.000000    2.000000    1.500000
   1.000000    0.800000    0.600000    0.500000    0.400000    0.300000
   0.200000    0.150000    0.100000    0.080000    0.060000    0.050000
   0.040000    0.030000    0.020000    0.015000    0.010000
```

```
TOTAL ATTENUATION COEFFICIENTS (CM2/G)
   0.017050    0.016850    0.016564    0.016390    0.016176    0.015804
   0.015305    0.014982    0.014581    0.014388    0.014258    0.014255
   0.014367    0.014721    0.015766    0.017000    0.019607    0.021559
   0.024697    0.027101    0.030488    0.035560    0.044352    0.051679
   0.063536    0.070708    0.080488    0.087010    0.095291    0.106341
   0.122420    0.133726    0.149314    0.157859    0.169894    0.178619
   0.193111    0.229818    0.386974    0.720744    2.163384
   2.163384    2.163384

RATIO OF SCATTERING PLUS PAIR PRODUCTION TO TOTAL ATTENUATION COEFFICIENTS
   1.000000    1.000000    1.000000    1.000000    1.000000    1.000000
   1.000000    1.000000    1.000000    1.000000    1.000000    1.000000
   1.000000    1.000000    1.000000    1.000000    1.000000    1.000000
   1.000000    1.000000    1.000000    1.000000    0.999989    0.999990
   0.999977    0.999965    0.999944    0.999914    0.999853    0.999694
   0.999062    0.997844    0.992746    0.985705    0.966057    0.945817
   0.901584    0.782021    0.480368    0.262506    0.089055
   0.089055    0.089055

RATIO OF SCATTERING TO SCATTERING PLUS PAIR PRODUCTION ATTENUATION COEFFICIENTS
   0.020611    0.025356    0.033030    0.038979    0.047708    0.062381
   0.090820    0.118356    0.170851    0.208490    0.266723    0.309835
   0.368237    0.452037    0.579835    0.670187    0.784891    0.838296
   0.894416    0.922380    0.949356    0.973713    0.992696    0.998477
   1.000000

IONIZATION DATA FOR SHELL  1

BINDING ENERGY (MEV), PHOTOEFFECT EFFICIENCY AND FLUORESCENT EFFICIENCY
   0.000284    0.961500    0.007000

 NUMK  NUMA
    1     1

X-RAY ENERGIES (MEV)
   0.000284

X-RAY ACCUMULATED RELATIVE INTENSITIES
   1.000000

AUGER ELECTRON ENERGIES (MEV)
   0.000284

AUGER ELECTRON ACCUMULATED RELATIVE INTENSITIES
   1.000000

     DETOUR   EXCI1(KEV)  AVGKE(KEV)
   0.860000    0.000000    0.000000

INPUT FROM DATAPAC

DATAPAC-6B, SET 35 - NYLON DYE FILM, 64-0.001 MEV, 8/2.      19 APR 84.

 NSET  ITRM  IZIP  ISGN  ISUB  INAL  ICYC  NCYC  NMAX      EMAX           EMIN           RMAX        LMAT
   35     5     0     1     2     1     1     8   128  6.4000000E+01  9.7656250E-04  2.4820480E+01     4

DATAPREP DATA FOR DATAPAC SET  35   128    33     2   121  2.482048E+01

COLLISION / TOTAL DE/DX RATIOS FOR DATAPAC SET  35

CUMULATIVE BREMSSTRAHLUNG CROSS SECTIONS FOR DATAPAC SET  35

CUMULATIVE BREMSSTRAHLUNG ANGULAR DISTRIBUTIONS FOR DATAPAC SET  35

LANGAUSS - EQUIPROBABLE ENDPOINTS FOR INTERPOLATION

K X-RAY PRODUCTION FOR DATAPAC SET  35

PHOTOELECTRON ANGULAR DISTRIBUTIONS

PAIR ELECTRON ENERGY DIVISION DISTRIBUTION (LEAD)

  MAT  EXCI1(MEV)  AVGKE(MEV)
    1  5.3241E-03  1.1370E-03
    2  4.7913E-02  9.0517E-03
    3  8.2691E-04  2.3414E-04
    4  3.5216E-04  1.5732E-04
```

```
NUMBER OF RUNS =  1                                  TOTAL TIME =  32.07 MIN (CPU =   0.38, IO =  31.68)
```

```
ZTRAN-4C, TEST RUN - 0.4 MEV, TI/AIR/NYLON/U, 10K/NAT.
 NRUN   INC ISTRG  INOK IPHOT  IBAD  IDES  ITER  IPSC  IPUN
    0     1     1     1     1     1     1     1     1     2

INCIDENT ELECTRONS

ELECTRON COLLISION AND RADIATION ENERGY LOSS STRAGGLING

KNOCK-ON ELECTRON PRODUCTION

BREMSSTRAHLUNG AND CHARACTERISTIC X-RAY QUANTA FOLLOWED

BREMSSTRAHLUNG INTRINSIC ANGLE OF EMISSION FROM TABULATED DISTRIBUTION

PHOTON-PRODUCED PARTICLES FOLLOWED

 LMAX  ITMK  JMAX  IPMK JPMAX  ISMK JSMAX  IAMK  KMAX  IBMK KPMAX  LMIX
    4     1    50     1    50     1    50     1    18     1    18     0

 IMAX  LDEP LZMAX LEFLX LEFMX  NCYC LPFLX LPFMX NPCYC NFCOS  LBIN
10000     4    -4     0     0     0     0     0     0     2     0

      INRAN
  301251933

        TIN        TCUT       TPCUT       TSAVE       ANGIN         ZIN
    0.40000     0.00105     0.01000     0.10000     0.00000     0.00000

       BNUM        XNUM        DLIM
    0.00000     0.00000     0.00000

SLAB THICKNESS IN G/CM2
    0.01153     0.01205     0.00579     0.25000

MATERIAL NUMBER FOR SLAB
          1           3           4           2

BOUNDARIES IN G/CM2
    0.00000     0.01153     0.02358     0.02937     0.27937

BOUNDARIES FOR ELECTRON DIFFERENTIAL DISTRIBUTIONS
    1     0     0     2

BOUNDARIES FOR PHOTON DIFFERENTIAL DISTRIBUTIONS
    0     0     0     0

ELECTRON ENERGY CLASSIFICATIONS (MEV)
    0.39200     0.38400     0.37600     0.36800     0.36000     0.35200
    0.34400     0.33600     0.32800     0.32000     0.31200     0.30400
    0.29600     0.28800     0.28000     0.27200     0.26400     0.25600
    0.24800     0.24000     0.23200     0.22400     0.21600     0.20800
    0.20000     0.19200     0.18400     0.17600     0.16800     0.16000
    0.15200     0.14400     0.13600     0.12800     0.12000     0.11200
    0.10400     0.09600     0.08800     0.08000     0.07200     0.06400
    0.05600     0.04800     0.04000     0.03200     0.02400     0.01600
    0.00800     0.00105

PHOTON ENERGY CLASSIFICATIONS (MEV)
    0.39200     0.38400     0.37600     0.36800     0.36000     0.35200
    0.34400     0.33600     0.32800     0.32000     0.31200     0.30400
    0.29600     0.28800     0.28000     0.27200     0.26400     0.25600
    0.24800     0.24000     0.23200     0.22400     0.21600     0.20800
    0.20000     0.19200     0.18400     0.17600     0.16800     0.16000
    0.15200     0.14400     0.13600     0.12800     0.12000     0.11200
    0.10400     0.09600     0.08800     0.08000     0.07200     0.06400
    0.05600     0.04800     0.04000     0.03200     0.02400     0.01600
    0.01000

COMPLIMENT OF ABSORBED ENERGY CLASSIFICATIONS (MEV)
    0.39200     0.38400     0.37600     0.36800     0.36000     0.35200
    0.34400     0.33600     0.32800     0.32000     0.31200     0.30400
    0.29600     0.28800     0.28000     0.27200     0.26400     0.25600
    0.24800     0.24000     0.23200     0.22400     0.21600     0.20800
    0.20000     0.19200     0.18400     0.17600     0.16800     0.16000
    0.15200     0.14400     0.13600     0.12800     0.12000     0.11200
    0.10400     0.09600     0.08800     0.08000     0.07200     0.06400
    0.05600     0.04800     0.04000     0.03200     0.02400     0.01600
    0.00800     0.00105
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ELECTRON OBLIQUITY CLASSIFICATIONS (DEGREES)
    5.00000    10.00000    15.00000    20.00000    25.00000    30.00000
   35.00000    40.00000    45.00000    50.00000    55.00000    60.00000
   65.00000    70.00000    75.00000    80.00000    85.00000    90.00000

PHOTON OBLIQUITY CLASSIFICATIONS (DEGREES)
    5.00000    10.00000    15.00000    20.00000    25.00000    30.00000
   35.00000    40.00000    45.00000    50.00000    55.00000    60.00000
   65.00000    70.00000    75.00000    80.00000    85.00000    90.00000

ENERGY DEPOSITION BOUNDARIES IN G/CM2
    0.01153     0.02358     0.02937     0.27937

NTFST JATIN SCALE SKALE        TCUT       TPCUT       TFCUT      TPFCUT       TSAVE        DLIM
   60   826     1     1     0.00105     0.01000     0.00000     0.00000     0.10000     1.00000

MATERIAL           1          2          3          4

  RANGE   1.8156E-01 2.5819E-01 1.4555E-01 1.2704E-01

  ATIN    8.9322E-02 2.7202E-01 9.5187E-02 9.5218E-02

  X-RAY            2          1          2          2

ANNIHILATION QUANTA FOLLOWED

  1000 HISTORIES COMPLETED

  2000 HISTORIES COMPLETED

  3000 HISTORIES COMPLETED

  4000 HISTORIES COMPLETED

  5000 HISTORIES COMPLETED

  6000 HISTORIES COMPLETED

  7000 HISTORIES COMPLETED

  8000 HISTORIES COMPLETED

  9000 HISTORIES COMPLETED

 10000 HISTORIES COMPLETED
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AVERAGE SOURCE ENERGY = 4.0000E-01 MEV

      INRAN           IRC            IRA
   301251933     1129353245      910539605

    ------------------------------------- HISTORIES --------------------------------------     REJ       REJ       ---- STEPS ---
   PRIM       SEC     KNOCK        P E       PAIR       COM     AUGER       BREM       RAD       XRAY     LAND       BLK        PRIM        SEC
   10000      4704     4615         88          0         1         0        874      2494         59      134      7569      219012      32250

                               ENERGY (MEV)          AVE ENERGY (MEV)        NUMBER/PRIMARY        NUMBER GENERATED
FIRST KNOCK (ABOVE TCUT)        8.8688E-02             4.5306E-03              1.9575E+01             198432
TOTAL KNOCK (ABOVE TCUT)        9.0514E-02             4.4830E-03              2.0190E+01             204587
PHOTO-ELECTRON                  2.3878E-03             3.4508E-02              6.9196E-02                692
PAIR                            0.0000E+00             0.0000E+00              0.0000E+00                  0
COMPTON                         2.4088E-05             2.0074E-02              1.2000E-03                 12
AUGER                           0.0000E+00             0.0000E+00              0.0000E+00                  0
FIRST BREMSSTRAHLUNG            4.8767E-03             1.9985E-02              2.4402E-01               2441
TOTAL BREMSSTRAHLUNG            4.8922E-03             1.9622E-02              2.4932E-01               2494
X-RAY                           6.0034E-04             1.0175E-01              5.9000E-03                 59
ANNIHILATION QUANTA             0.0000E+00             0.0000E+00              0.0000E+00                  0

UNSCATTERED PRIMARY PHOTONS
  0.000E+00   0.000E+00   0.000E+00   0.000E+00

NUMBER COEFFICIENTS - KNOCK-ONS, PHOTON DESCENDANTS

                                                    TRANSMISSION
  1.720E-02   1.920E-02   2.000E-02   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   5.000E-04

                                                     REFLECTION
  6.700E-03   1.440E-02   1.400E-02   3.240E-02
  0.000E+00   0.000E+00   0.000E+00   6.000E-04

ENERGY COEFFICIENTS - KNOCK-ONS, PHOTON DESCENDANTS

                                                    TRANSMISSION
  1.994E-03   2.059E-03   2.087E-03   0.000E+00
  0.000E+00   0.000E+00   0.000E+00   2.010E-04

                                                     REFLECTION
  6.550E-04   1.269E-03   1.341E-03   2.539E-03
  0.000E+00   0.000E+00   0.000E+00   7.219E-05
```

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                                         NUMBER AND ENERGY COEFFICIENTS

                                                 TRANSMISSION

                                                   +---------- ELECTRON ---------+      +----------- PHOTON ----------+
SLAB  MATERIAL          Z (G/CM2)                   NUMBER      ENERGY       COUNTS       NUMBER      ENERGY       COUNTS

  1       1        0.000E+00 - 1.153E-02          1.145E+00   9.887E-01     11453       2.237E-03   3.076E-04         25
  2       3        1.153E-02 - 2.358E-02          1.110E+00   8.741E-01     11105       3.770E-03   5.246E-04         41
  3       4        2.358E-02 - 2.937E-02          1.083E+00   8.101E-01     10831       4.340E-03   6.099E-04         47
  4       2        2.937E-02 - 2.794E-01          5.000E-04   2.010E-04         5       6.205E-03   2.150E-03        522

                                                  REFLECTION

                                                   +---------- ELECTRON ---------+      +----------- PHOTON ----------+
SLAB  MATERIAL          Z (G/CM2)                   NUMBER      ENERGY       COUNTS       NUMBER      ENERGY       COUNTS

  1       1        0.000E+00 - 1.153E-02          2.995E-01   1.533E-01      2996       1.719E-02   3.366E-03        372
  2       3        1.153E-02 - 2.358E-02          5.035E-01   2.589E-01      5037       1.801E-02   3.373E-03        355
  3       4        2.358E-02 - 2.937E-02          6.018E-01   3.488E-01      6021       1.716E-02   3.315E-03        344
  4       2        2.937E-02 - 2.794E-01          6.739E-01   4.072E-01      6742       1.684E-02   3.308E-03        340
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                                   ENERGY AND CHARGE DEPOSITION
                                (NORMALIZED TO ONE INCIDENT PARTICLE)

          Z                  ENERGY DEPOSITION (MEV CM2/G)            CHARGE DEPOSITION (ELEC CM2/G)
       (G/CM2)               PRIM      KNOCK     G-SEC     TOTAL       PRIM      KNOCK     G-SEC     TOTAL

0.000E+00 - 1.153E-02     2.85E+00  1.10E+00  4.03E-03  3.95E+00    5.91E+00 -8.95E-01  0.00E+00  5.02E+00
1.153E-02 - 2.358E-02     5.09E+00  1.65E+00  5.52E-04  6.74E+00    1.13E+01  1.73E-01  0.00E+00  1.14E+01
2.358E-02 - 2.937E-02     6.27E+00  2.13E+00  4.52E-03  8.40E+00    1.40E+01  3.28E-01  1.04E-01  1.45E+01
2.937E-02 - 2.794E-01     4.30E-01  1.72E-01  9.09E-03  6.12E-01    1.69E+00 -2.74E-03 -4.40E-03  1.68E+00

        TOTAL             2.38E-01  8.81E-02  2.35E-03  3.28E-01    7.07E-01 -7.02E-03 -5.00E-04  6.99E-01
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                                        SPECTRA OF ABSORBED ENERGY
                              (NUMBER/MEV, NORMALIZED TO ONE INCIDENT PARTICLE)

                MATERIAL  1         3          4          2

   E (MEV)      Z=0.00E+00  1.15E-02  2.36E-02  2.94E-02
                  1.15E-02  2.36E-02  2.94E-02  2.79E-01

0.0000 -  0.0080   2.97E+00  3.20E+00  7.66E+00  1.91E+01
0.0080 -  0.0160   3.02E+01  2.70E+00  2.73E+01  7.24E+00
0.0160 -  0.0240   2.30E+01  2.11E+01  1.43E+01  5.96E+00
0.0240 -  0.0320   9.66E+00  1.26E+01  1.52E+01  4.77E+00
0.0320 -  0.0400   1.00E+01  6.54E+00  1.17E+01  4.49E+00
0.0400 -  0.0480   8.45E+00  8.07E+00  7.91E+00  3.66E+00
0.0480 -  0.0560   6.66E+00  8.20E+00  5.61E+00  3.49E+00
0.0560 -  0.0640   5.17E+00  6.31E+00  4.51E+00  2.94E+00
0.0640 -  0.0720   4.35E+00  5.96E+00  3.77E+00  2.32E+00
0.0720 -  0.0800   3.72E+00  4.49E+00  2.76E+00  2.31E+00
0.0800 -  0.0880   2.90E+00  4.09E+00  2.61E+00  2.02E+00
0.0880 -  0.0960   2.47E+00  3.76E+00  2.25E+00  1.89E+00
0.0960 -  0.1040   1.97E+00  2.56E+00  2.25E+00  1.52E+00
0.1040 -  0.1120   1.82E+00  2.59E+00  2.00E+00  1.44E+00
0.1120 -  0.1200   1.45E+00  2.42E+00  2.01E+00  1.30E+00
0.1200 -  0.1280   1.22E+00  2.39E+00  1.94E+00  1.24E+00
0.1280 -  0.1360   1.24E+00  2.21E+00  1.51E+00  1.30E+00
0.1360 -  0.1440   9.87E-01  1.96E+00  1.22E+00  1.01E+00
0.1440 -  0.1520   9.62E-01  1.97E+00  1.06E+00  1.00E+00
0.1520 -  0.1600   9.75E-01  2.17E+00  9.38E-01  1.10E+00
0.1600 -  0.1680   7.75E-01  2.04E+00  1.00E+00  1.15E+00
0.1680 -  0.1760   5.00E-01  1.70E+00  8.37E-01  1.19E+00
0.1760 -  0.1840   5.50E-01  1.39E+00  7.00E-01  9.13E-01
0.1840 -  0.1920   4.50E-01  1.42E+00  5.00E-01  8.87E-01
0.1920 -  0.2000   4.12E-01  1.64E+00  4.87E-01  8.62E-01
0.2000 -  0.2080   4.00E-01  1.42E+00  3.75E-01  7.38E-01
0.2080 -  0.2160   2.62E-01  1.49E+00  3.87E-01  8.12E-01
0.2160 -  0.2240   2.12E-01  1.11E+00  3.25E-01  7.50E-01
0.2240 -  0.2320   2.63E-01  1.05E+00  3.50E-01  8.63E-01
0.2320 -  0.2400   1.87E-01  8.12E-01  2.25E-01  7.87E-01
0.2400 -  0.2480   2.00E-01  1.02E+00  2.87E-01  9.62E-01
0.2480 -  0.2560   1.62E-01  6.75E-01  2.00E-01  7.25E-01
0.2560 -  0.2640   1.00E-01  6.13E-01  1.25E-01  8.50E-01
0.2640 -  0.2720   6.25E-02  6.12E-01  7.50E-02  7.87E-01
0.2720 -  0.2800   8.75E-02  5.00E-01  1.37E-01  7.37E-01
0.2800 -  0.2880   2.50E-02  3.25E-01  3.75E-02  9.13E-01
0.2880 -  0.2960   1.25E-02  2.87E-01  8.75E-02  1.04E+00
0.2960 -  0.3040   6.25E-02  3.37E-01  3.75E-02  1.20E+00
0.3040 -  0.3120   3.75E-02  2.00E-01  1.25E-02  1.69E+00
0.3120 -  0.3200   0.00E+00  2.50E-01  7.50E-02  2.39E+00
0.3200 -  0.3280   0.00E+00  1.25E-01  2.50E-02  3.11E+00
0.3280 -  0.3360   0.00E+00  1.63E-01  1.25E-02  4.91E+00
0.3360 -  0.3440   1.25E-02  1.00E-01  3.75E-02  7.44E+00
0.3440 -  0.3520   0.00E+00  1.00E-01  0.00E+00  9.10E+00
0.3520 -  0.3600   0.00E+00  8.75E-02  0.00E+00  8.05E+00
0.3600 -  0.3680   0.00E+00  3.75E-02  0.00E+00  1.77E+00
0.3680 -  0.3760   0.00E+00  3.75E-02  0.00E+00  8.75E-02
0.3760 -  0.3840   0.00E+00  6.25E-02  0.00E+00  2.50E-02
0.3840 -  0.3920   0.00E+00  3.75E-02  0.00E+00  1.25E-02
0.3920 -  0.3989   0.00E+00  0.00E+00  0.00E+00  0.00E+00

TOTAL ABSORPTION   0.00E+00  0.00E+00  0.00E+00  1.30E-03

   EFFICIENCY      1.00E+00  1.00E+00  1.00E+00  1.00E+00

 PHOTOFRACTION     0.00E+00  0.00E+00  0.00E+00  1.30E-03
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                                           ENERGY SPECTRA OF TRANSMITTED ELECTRONS
                                        (NUMBER/MEV, NORMALIZED TO ONE INCIDENT PARTICLE)

                    MATERIAL  1          3          4          2

         E (MEV)       Z=1.15E-02  2.36E-02  2.94E-02  2.79E-01

      0.4000 -   0.3920   3.64E+00  0.00E+00  0.00E+00  0.00E+00
      0.3920 -   0.3840   5.56E+01  1.25E-02  0.00E+00  0.00E+00
      0.3840 -   0.3760   4.11E+01  7.62E-01  0.00E+00  0.00E+00
      0.3760 -   0.3680   1.08E+01  1.31E+01  1.50E-01  0.00E+00
      0.3680 -   0.3600   4.42E+00  3.40E+01  4.39E+00  0.00E+00
      0.3600 -   0.3520   2.37E+00  2.39E+01  1.93E+01  0.00E+00
      0.3520 -   0.3440   1.26E+00  1.46E+01  2.34E+01  0.00E+00
      0.3440 -   0.3360   8.00E-01  9.62E+00  1.91E+01  0.00E+00
      0.3360 -   0.3280   6.50E-01  5.85E+00  1.24E+01  0.00E+00
      0.3280 -   0.3200   5.00E-01  3.67E+00  8.71E+00  0.00E+00
      0.3200 -   0.3120   3.25E-01  2.64E+00  6.36E+00  0.00E+00
      0.3120 -   0.3040   3.25E-01  1.76E+00  4.76E+00  0.00E+00
      0.3040 -   0.2960   2.38E-01  1.30E+00  3.06E+00  0.00E+00
      0.2960 -   0.2880   2.37E-01  1.35E+00  2.47E+00  0.00E+00
      0.2880 -   0.2800   1.50E-01  1.14E+00  2.00E+00  0.00E+00
      0.2800 -   0.2720   3.62E-01  8.37E-01  1.70E+00  0.00E+00
      0.2720 -   0.2640   3.63E-01  8.13E-01  1.27E+00  0.00E+00
      0.2640 -   0.2560   4.50E-01  6.50E-01  1.29E+00  0.00E+00
      0.2560 -   0.2480   3.50E-01  7.00E-01  1.52E+00  0.00E+00
      0.2480 -   0.2400   5.38E-01  8.13E-01  1.00E+00  0.00E+00
      0.2400 -   0.2320   4.75E-01  8.00E-01  1.00E+00  0.00E+00
      0.2320 -   0.2240   6.62E-01  9.62E-01  9.75E-01  1.25E-02
      0.2240 -   0.2160   6.13E-01  7.75E-01  6.88E-01  0.00E+00
      0.2160 -   0.2080   6.25E-01  6.25E-01  8.12E-01  0.00E+00
      0.2080 -   0.2000   4.87E-01  7.50E-01  9.37E-01  0.00E+00
      0.2000 -   0.1920   5.88E-01  9.50E-01  9.38E-01  0.00E+00
      0.1920 -   0.1840   8.50E-01  8.37E-01  9.87E-01  0.00E+00
      0.1840 -   0.1760   7.12E-01  8.62E-01  8.37E-01  1.25E-02
      0.1760 -   0.1680   7.50E-01  6.63E-01  9.50E-01  1.25E-02
      0.1680 -   0.1600   8.25E-01  7.75E-01  8.75E-01  0.00E+00
      0.1600 -   0.1520   6.25E-01  8.37E-01  9.25E-01  0.00E+00
      0.1520 -   0.1440   7.87E-01  9.62E-01  8.25E-01  1.25E-02
      0.1440 -   0.1360   7.38E-01  6.25E-01  7.63E-01  0.00E+00
      0.1360 -   0.1280   9.62E-01  7.75E-01  6.50E-01  0.00E+00
      0.1280 -   0.1200   6.12E-01  7.87E-01  9.50E-01  0.00E+00
      0.1200 -   0.1120   7.25E-01  9.00E-01  9.25E-01  0.00E+00
      0.1120 -   0.1040   6.25E-01  6.87E-01  7.00E-01  0.00E+00
      0.1040 -   0.0960   5.62E-01  7.37E-01  6.62E-01  0.00E+00
      0.0960 -   0.0880   7.50E-01  6.38E-01  6.75E-01  0.00E+00
      0.0880 -   0.0800   4.25E-01  5.62E-01  6.75E-01  0.00E+00
      0.0800 -   0.0720   6.50E-01  7.62E-01  5.75E-01  1.25E-02
      0.0720 -   0.0640   6.00E-01  7.63E-01  6.75E-01  0.00E+00
      0.0640 -   0.0560   6.87E-01  5.25E-01  6.87E-01  0.00E+00
      0.0560 -   0.0480   5.87E-01  6.00E-01  6.50E-01  0.00E+00
      0.0480 -   0.0400   5.63E-01  5.25E-01  6.75E-01  0.00E+00
      0.0400 -   0.0320   4.87E-01  6.62E-01  4.25E-01  0.00E+00
      0.0320 -   0.0240   4.50E-01  4.75E-01  6.50E-01  0.00E+00
      0.0240 -   0.0160   3.62E-01  6.00E-01  4.87E-01  0.00E+00
      0.0160 -   0.0080   5.00E-01  5.63E-01  5.88E-01  0.00E+00
      0.0080 -   0.0011   3.88E-01  4.46E-01  3.60E-01  0.00E+00
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                                     ENERGY SPECTRA OF REFLECTED ELECTRONS
                                 (NUMBER/MEV, NORMALIZED TO ONE INCIDENT PARTICLE)
              MATERIAL  1         3          4          2

     E (MEV)       Z=0.00E+00  1.15E-02  2.36E-02  2.94E-02

0.4000 -  0.3920   1.25E-02  0.00E+00  0.00E+00  0.00E+00
0.3920 -  0.3840   7.50E-02  0.00E+00  0.00E+00  0.00E+00
0.3840 -  0.3760   1.87E-01  0.00E+00  0.00E+00  0.00E+00
0.3760 -  0.3680   2.75E-01  0.00E+00  0.00E+00  0.00E+00
0.3680 -  0.3600   3.75E-01  1.25E-01  0.00E+00  1.25E-01
0.3600 -  0.3520   2.00E-01  2.25E-01  0.00E+00  7.62E-01
0.3520 -  0.3440   2.63E-01  2.63E-01  2.38E-01  2.27E+00
0.3440 -  0.3360   2.75E-01  2.38E-01  6.75E-01  4.14E+00
0.3360 -  0.3280   2.62E-01  3.25E-01  1.79E+00  4.77E+00
0.3280 -  0.3200   3.00E-01  3.88E-01  2.96E+00  4.82E+00
0.3200 -  0.3120   3.00E-01  6.50E-01  3.17E+00  5.25E+00
0.3120 -  0.3040   2.87E-01  1.19E+00  4.42E+00  5.66E+00
0.3040 -  0.2960   3.88E-01  1.97E+00  4.35E+00  4.47E+00
0.2960 -  0.2880   5.00E-01  1.94E+00  4.31E+00  4.05E+00
0.2880 -  0.2800   9.37E-01  2.72E+00  4.51E+00  3.37E+00
0.2800 -  0.2720   1.12E+00  2.69E+00  4.04E+00  3.16E+00
0.2720 -  0.2640   1.15E+00  2.91E+00  3.06E+00  2.95E+00
0.2640 -  0.2560   1.41E+00  3.09E+00  3.40E+00  2.74E+00
0.2560 -  0.2480   1.54E+00  3.17E+00  3.31E+00  2.41E+00
0.2480 -  0.2400   1.95E+00  3.02E+00  2.67E+00  2.11E+00
0.2400 -  0.2320   1.72E+00  3.17E+00  2.77E+00  1.95E+00
0.2320 -  0.2240   1.64E+00  2.70E+00  2.09E+00  1.72E+00
0.2240 -  0.2160   1.74E+00  2.69E+00  2.04E+00  1.70E+00
0.2160 -  0.2080   2.05E+00  2.10E+00  2.09E+00  1.36E+00
0.2080 -  0.2000   1.94E+00  2.10E+00  1.91E+00  1.44E+00
0.2000 -  0.1920   1.79E+00  1.92E+00  1.76E+00  1.35E+00
0.1920 -  0.1840   1.46E+00  1.76E+00  1.34E+00  1.27E+00
0.1840 -  0.1760   1.40E+00  1.94E+00  1.60E+00  1.37E+00
0.1760 -  0.1680   1.32E+00  1.60E+00  1.27E+00  1.29E+00
0.1680 -  0.1600   1.19E+00  1.59E+00  1.06E+00  1.12E+00
0.1600 -  0.1520   1.30E+00  1.66E+00  1.31E+00  9.37E-01
0.1520 -  0.1440   8.37E-01  1.29E+00  1.09E+00  1.11E+00
0.1440 -  0.1360   7.88E-01  1.30E+00  1.11E+00  8.38E-01
0.1360 -  0.1280   7.87E-01  1.11E+00  7.75E-01  8.37E-01
0.1280 -  0.1200   7.37E-01  1.01E+00  1.10E+00  8.00E-01
0.1200 -  0.1120   8.00E-01  1.29E+00  9.50E-01  8.63E-01
0.1120 -  0.1040   5.00E-01  9.75E-01  8.50E-01  7.62E-01
0.1040 -  0.0960   6.87E-01  8.75E-01  6.00E-01  8.37E-01
0.0960 -  0.0880   3.88E-01  7.75E-01  7.13E-01  9.00E-01
0.0880 -  0.0800   5.50E-01  8.12E-01  6.75E-01  6.75E-01
0.0800 -  0.0720   4.00E-01  6.50E-01  7.25E-01  1.06E+00
0.0720 -  0.0640   3.38E-01  7.75E-01  5.00E-01  8.38E-01
0.0640 -  0.0560   1.87E-01  7.37E-01  6.62E-01  5.75E-01
0.0560 -  0.0480   1.87E-01  5.37E-01  6.87E-01  8.25E-01
0.0480 -  0.0400   2.13E-01  4.63E-01  4.25E-01  7.50E-01
0.0400 -  0.0320   1.25E-01  3.87E-01  5.50E-01  6.00E-01
0.0320 -  0.0240   1.75E-01  5.00E-01  4.75E-01  5.75E-01
0.0240 -  0.0160   1.50E-01  4.50E-01  4.50E-01  7.37E-01
0.0160 -  0.0080   1.38E-01  5.50E-01  5.50E-01  9.00E-01
0.0080 -  0.0011   1.15E-01  3.60E-01  2.30E-01  1.35E+00
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                                        ANGULAR DISTRIBUTIONS OF TRANSMITTED ELECTRONS
                                       (NUMBER/SR, NORMALIZED TO ONE INCIDENT PARTICLE)

              MATERIAL  1          3          4          2

   THETA (DEG)    Z=1.15E-02  2.36E-02  2.94E-02  2.79E-01

  0.0000 -  5.0000   8.41E-01  6.82E-01  5.19E-01  0.00E+00
  5.0000 - 10.0000   8.13E-01  5.83E-01  5.16E-01  0.00E+00
 10.0000 - 15.0000   7.52E-01  5.84E-01  5.26E-01  8.43E-04
 15.0000 - 20.0000   6.75E-01  5.24E-01  4.29E-01  0.00E+00
 20.0000 - 25.0000   5.70E-01  4.70E-01  4.41E-01  0.00E+00
 25.0000 - 30.0000   4.91E-01  4.08E-01  4.04E-01  1.19E-03
 30.0000 - 35.0000   3.96E-01  3.40E-01  3.60E-01  0.00E+00
 35.0000 - 40.0000   3.19E-01  3.14E-01  3.00E-01  0.00E+00
 40.0000 - 45.0000   2.50E-01  2.56E-01  2.64E-01  0.00E+00
 45.0000 - 50.0000   1.75E-01  2.06E-01  1.92E-01  0.00E+00
 50.0000 - 55.0000   1.37E-01  1.68E-01  1.64E-01  0.00E+00
 55.0000 - 60.0000   1.02E-01  1.43E-01  1.53E-01  0.00E+00
 60.0000 - 65.0000   8.06E-02  9.77E-02  1.08E-01  0.00E+00
 65.0000 - 70.0000   5.49E-02  8.53E-02  8.29E-02  0.00E+00
 70.0000 - 75.0000   4.97E-02  6.77E-02  6.41E-02  0.00E+00
 75.0000 - 80.0000   3.29E-02  4.11E-02  4.88E-02  0.00E+00
 80.0000 - 85.0000   2.06E-02  2.87E-02  3.33E-02  1.84E-04
 85.0000 - 90.0000   1.44E-02  1.66E-02  1.92E-02  0.00E+00
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                                        ANGULAR DISTRIBUTIONS OF REFLECTED ELECTRONS
                                      (NUMBER/SR, NORMALIZED TO ONE INCIDENT PARTICLE)

               MATERIAL  1          3          4          2

   THETA (DEG)     Z=0.00E+00  1.15E-02  2.36E-02  2.94E-02

  0.0000 -  5.0000   1.51E-01  2.05E-01  1.67E-01  2.17E-01
  5.0000 - 10.0000   1.09E-01  1.91E-01  2.00E-01  1.97E-01
 10.0000 - 15.0000   1.10E-01  1.68E-01  1.92E-01  2.03E-01
 15.0000 - 20.0000   1.03E-01  1.87E-01  2.00E-01  1.94E-01
 20.0000 - 25.0000   9.96E-02  1.73E-01  1.86E-01  1.89E-01
 25.0000 - 30.0000   1.01E-01  1.53E-01  1.67E-01  1.72E-01
 30.0000 - 35.0000   8.11E-02  1.46E-01  1.60E-01  1.76E-01
 35.0000 - 40.0000   7.52E-02  1.26E-01  1.53E-01  1.36E-01
 40.0000 - 45.0000   7.51E-02  1.09E-01  1.32E-01  1.61E-01
 45.0000 - 50.0000   6.41E-02  9.70E-02  1.27E-01  1.46E-01
 50.0000 - 55.0000   5.77E-02  9.40E-02  1.09E-01  1.22E-01
 55.0000 - 60.0000   4.02E-02  7.87E-02  1.04E-01  1.16E-01
 60.0000 - 65.0000   3.72E-02  6.56E-02  8.78E-02  1.05E-01
 65.0000 - 70.0000   3.36E-02  5.79E-02  6.95E-02  8.53E-02
 70.0000 - 75.0000   2.43E-02  4.23E-02  5.74E-02  6.85E-02
 75.0000 - 80.0000   1.68E-02  2.73E-02  3.85E-02  5.40E-02
 80.0000 - 85.0000   1.01E-02  2.10E-02  2.98E-02  4.18E-02
 85.0000 - 90.0000   5.48E-03  1.53E-02  1.52E-02  2.06E-02
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                  ENERGY SPECTRA AND ANGULAR DISTRIBUTIONS OF ELECTRONS TRANSMITTED THROUGH
                                         SLAB  1 MADE OF MATERIAL  1
                            (NUMBER/(MEVxSR), NORMALIZED TO ONE INCIDENT PARTICLE)

   E (MEV)  THETA=  0.000     5.000     10.000    15.000    20.000    25.000    30.000    35.000    40.000    45.000
                    5.000     10.000    15.000    20.000    25.000    30.000    35.000    40.000    45.000    50.000

0.4000 -  0.3920  4.18E+00  3.14E+00  3.27E+00  2.96E+00  2.32E+00  1.83E+00  1.06E+00  1.20E+00  8.44E-01  4.64E-01
0.3920 -  0.3840  5.44E+01  5.19E+01  4.49E+01  3.96E+01  3.27E+01  2.83E+01  2.24E+01  1.54E+01  1.19E+01  7.39E+00
0.3840 -  0.3760  3.35E+01  3.11E+01  2.82E+01  2.51E+01  2.13E+01  1.86E+01  1.43E+01  1.29E+01  9.21E+00  6.40E+00
0.3760 -  0.3680  7.32E+00  4.89E+00  6.11E+00  6.07E+00  4.53E+00  3.26E+00  4.33E+00  3.03E+00  2.67E+00  1.67E+00
0.3680 -  0.3600  2.09E+00  2.97E+00  1.90E+00  2.20E+00  2.56E+00  1.98E+00  1.32E+00  9.74E-01  1.55E+00  8.35E-01
0.3600 -  0.3520  1.05E+00  1.05E+00  1.58E+00  1.59E+00  1.25E+00  1.09E+00  6.79E-01  4.12E-01  4.73E-01  4.64E-01
0.3520 -  0.3440  5.23E-01  6.99E-01  8.43E-01  6.83E-01  2.38E-01  3.95E-01  5.09E-01  2.25E-01  2.03E-01  2.47E-01
0.3440 -  0.3360  0.00E+00  8.74E-01  7.38E-01  3.79E-01  1.79E-01  4.94E-01  1.70E-01  1.87E-01  1.35E-01  0.00E+00
0.3360 -  0.3280  0.00E+00  5.24E-01  1.05E-01  3.79E-01  1.19E-01  3.46E-01  1.70E-01  2.25E-01  6.75E-02  9.28E-02
0.3280 -  0.3200  0.00E+00  0.00E+00  7.38E-01  7.58E-02  3.58E-01  9.88E-02  8.49E-02  7.49E-02  6.75E-02  6.19E-02
0.3200 -  0.3120  5.23E-01  0.00E+00  2.11E-01  7.58E-02  0.00E+00  9.88E-02  1.70E-01  1.87E-01  3.38E-02  6.19E-02
0.3120 -  0.3040  0.00E+00  0.00E+00  0.00E+00  0.00E+00  1.19E-01  4.94E-02  0.00E+00  1.87E-01  3.38E-02  9.28E-02
0.3040 -  0.2960  0.00E+00  0.00E+00  1.05E-01  3.03E-01  1.79E-01  4.94E-02  0.00E+00  3.75E-02  0.00E+00  6.19E-02
0.2960 -  0.2880  0.00E+00  1.75E-01  0.00E+00  1.52E-01  0.00E+00  0.00E+00  4.24E-02  0.00E+00  1.01E-01  6.19E-02
0.2880 -  0.2800  0.00E+00  0.00E+00  0.00E+00  7.58E-02  0.00E+00  4.94E-02  0.00E+00  3.75E-02  0.00E+00  1.24E-01
0.2800 -  0.2720  0.00E+00  3.49E-01  1.05E-01  7.58E-02  1.19E-01  4.94E-02  4.24E-02  1.12E-01  1.01E-01  6.19E-02
0.2720 -  0.2640  0.00E+00  1.75E-01  2.11E-01  7.58E-02  5.96E-02  4.94E-02  8.49E-02  3.75E-02  6.75E-02  0.00E+00
0.2640 -  0.2560  0.00E+00  0.00E+00  2.11E-01  1.52E-01  1.19E-01  4.94E-02  8.49E-02  1.87E-01  6.75E-02  3.09E-02
0.2560 -  0.2480  0.00E+00  0.00E+00  1.05E-01  7.58E-02  0.00E+00  0.00E+00  1.27E-01  7.49E-02  1.01E-01  3.09E-02
0.2480 -  0.2400  0.00E+00  3.49E-01  0.00E+00  7.58E-02  0.00E+00  1.48E-01  4.24E-02  7.49E-02  1.01E-01  1.86E-01
0.2400 -  0.2320  0.00E+00  0.00E+00  1.05E-01  1.52E-01  2.38E-01  4.94E-02  1.27E-01  1.87E-01  1.01E-01  1.24E-01
0.2320 -  0.2240  0.00E+00  0.00E+00  2.11E-01  7.58E-02  0.00E+00  1.48E-01  1.70E-01  3.75E-02  1.35E-01  2.47E-01
0.2240 -  0.2160  0.00E+00  0.00E+00  0.00E+00  0.00E+00  1.79E-01  1.98E-01  4.24E-02  0.00E+00  1.35E-01  9.28E-02
0.2160 -  0.2080  0.00E+00  0.00E+00  1.05E-01  0.00E+00  0.00E+00  9.88E-02  1.27E-01  1.50E-01  1.69E-01  6.19E-02
0.2080 -  0.2000  0.00E+00  0.00E+00  2.11E-01  0.00E+00  2.38E-01  0.00E+00  1.27E-01  2.25E-01  1.35E-01  9.28E-02
0.2000 -  0.1920  0.00E+00  0.00E+00  0.00E+00  7.58E-02  2.98E-01  0.00E+00  8.49E-02  1.87E-01  3.38E-02  1.86E-01
0.1920 -  0.1840  0.00E+00  1.75E-01  0.00E+00  1.52E-01  1.19E-01  3.46E-01  1.70E-01  1.12E-01  1.35E-01  2.47E-01
0.1840 -  0.1760  0.00E+00  0.00E+00  1.05E-01  2.28E-01  5.96E-02  9.88E-02  1.70E-01  1.50E-01  1.01E-01  1.86E-01
0.1760 -  0.1680  0.00E+00  3.49E-01  0.00E+00  7.58E-02  2.38E-01  1.98E-01  2.12E-01  2.25E-01  1.69E-01  0.00E+00
0.1680 -  0.1600  0.00E+00  1.75E-01  2.11E-01  1.52E-01  1.79E-01  9.88E-02  1.27E-01  1.50E-01  1.35E-01  9.28E-02
0.1600 -  0.1520  0.00E+00  0.00E+00  0.00E+00  1.52E-01  2.98E-01  1.48E-01  2.12E-01  7.49E-02  2.70E-01  3.09E-02
0.1520 -  0.1440  0.00E+00  1.75E-01  3.16E-01  3.79E-01  2.98E-01  4.94E-02  1.27E-01  3.00E-01  1.69E-01  1.55E-01
0.1440 -  0.1360  0.00E+00  3.49E-01  1.05E-01  1.52E-01  2.38E-01  9.88E-02  8.49E-02  1.50E-01  1.01E-01  1.24E-01
0.1360 -  0.1280  0.00E+00  1.75E-01  2.11E-01  3.03E-01  2.98E-01  4.94E-01  2.55E-01  7.49E-02  2.36E-01  2.47E-01
0.1280 -  0.1200  0.00E+00  5.24E-01  1.05E-01  1.52E-01  2.38E-01  1.48E-01  2.12E-01  1.50E-01  6.75E-02  9.28E-02
0.1200 -  0.1120  0.00E+00  1.75E-01  1.05E-01  1.52E-01  5.96E-02  2.47E-01  8.49E-02  2.62E-01  1.01E-01  1.86E-01
0.1120 -  0.1040  5.23E-01  0.00E+00  2.11E-01  2.28E-01  2.38E-01  2.47E-01  4.24E-02  2.25E-01  3.38E-02  1.55E-01
0.1040 -  0.0960  0.00E+00  1.75E-01  4.21E-01  7.58E-02  0.00E+00  9.88E-02  1.70E-01  7.49E-02  6.75E-02  1.24E-01
0.0960 -  0.0880  0.00E+00  0.00E+00  5.27E-01  1.52E-01  0.00E+00  9.88E-02  1.70E-01  2.25E-01  1.01E-01  2.17E-01
0.0880 -  0.0800  0.00E+00  0.00E+00  1.05E-01  1.52E-01  5.96E-02  2.96E-01  1.70E-01  1.12E-01  6.75E-02  3.09E-02
0.0800 -  0.0720  0.00E+00  1.75E-01  3.16E-01  1.52E-01  1.79E-01  1.48E-01  8.49E-02  1.87E-01  1.35E-01  9.28E-02
0.0720 -  0.0640  0.00E+00  0.00E+00  0.00E+00  2.28E-01  1.79E-01  4.94E-02  1.70E-01  1.87E-01  1.35E-01  1.24E-01
0.0640 -  0.0560  5.23E-01  3.49E-01  2.11E-01  3.79E-01  1.79E-01  1.48E-01  8.49E-02  1.12E-01  1.01E-01  9.28E-02
0.0560 -  0.0480  0.00E+00  1.75E-01  4.21E-01  1.52E-01  2.38E-01  9.88E-02  2.55E-01  1.87E-01  1.01E-01  6.19E-02
0.0480 -  0.0400  0.00E+00  0.00E+00  0.00E+00  7.58E-02  5.96E-02  2.96E-01  4.24E-02  1.12E-01  1.01E-01  9.28E-02
0.0400 -  0.0320  0.00E+00  0.00E+00  3.16E-01  7.58E-02  2.98E-01  1.98E-01  8.49E-02  1.50E-01  0.00E+00  6.19E-02
0.0320 -  0.0240  0.00E+00  1.75E-01  0.00E+00  1.52E-01  2.98E-01  4.94E-02  4.24E-02  1.12E-01  1.01E-01  1.86E-01
0.0240 -  0.0160  5.23E-01  1.75E-01  1.05E-01  7.58E-02  5.96E-02  0.00E+00  0.00E+00  1.12E-01  6.75E-02  9.28E-02
0.0160 -  0.0080  0.00E+00  1.75E-01  2.11E-01  7.58E-02  2.38E-01  9.88E-02  8.49E-02  1.12E-01  1.35E-01  3.09E-02
0.0080 -  0.0011  0.00E+00  0.00E+00  0.00E+00  1.75E-01  6.86E-02  1.14E-01  1.95E-01  8.62E-02  1.55E-01  7.12E-02
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             ENERGY SPECTRA AND ANGULAR DISTRIBUTIONS OF ELECTRONS TRANSMITTED THROUGH
                                  SLAB  1 MADE OF MATERIAL  1
                     (NUMBER/(MEV*SR), NORMALIZED TO ONE INCIDENT PARTICLE)

    E (MEV)  THETA= 50.000     55.000     60.000     65.000     70.000     75.000     80.000     85.000
                    55.000     60.000     65.000     70.000     75.000     80.000     85.000     90.000

0.4000 -  0.3920   3.74E-01  1.08E-01  2.57E-02  4.94E-02  2.39E-02  2.34E-02  0.00E+00  0.00E+00
0.3920 -  0.3840   5.15E+00  2.78E+00  1.80E+00  9.13E-01  7.65E-01  3.97E-01  1.61E-01  4.57E-02
0.3840 -  0.3760   4.28E+00  3.38E+00  2.44E+00  1.68E+00  1.24E+00  8.18E-01  3.91E-01  2.74E-01
0.3760 -  0.3680   1.41E+00  1.41E+00  1.03E+00  6.42E-01  5.26E-01  5.61E-01  2.30E-01  1.37E-01
0.3680 -  0.3600   4.02E-01  4.06E-01  2.57E-01  2.47E-01  2.15E-01  2.10E-01  4.60E-02  9.13E-02
0.3600 -  0.3520   2.59E-01  2.16E-01  2.06E-01  1.73E-01  1.91E-01  4.67E-02  9.20E-02  2.28E-02
0.3520 -  0.3440   1.72E-01  2.16E-01  1.03E-01  9.87E-02  1.67E-01  4.67E-02  4.60E-02  4.57E-02
0.3440 -  0.3360   1.15E-01  1.08E-01  7.71E-02  7.41E-02  9.56E-02  4.67E-02  0.00E+00  2.28E-02
0.3360 -  0.3280   1.72E-01  0.00E+00  1.03E-01  4.94E-02  4.78E-02  4.67E-02  4.60E-02  2.28E-02
0.3280 -  0.3200   1.15E-01  2.70E-02  1.29E-01  7.41E-02  4.78E-02  0.00E+00  2.30E-02  0.00E+00
0.3200 -  0.3120   2.87E-02  5.41E-02  2.57E-02  0.00E+00  7.17E-02  2.34E-02  0.00E+00  0.00E+00
0.3120 -  0.3040   8.62E-02  8.11E-02  2.57E-02  2.47E-02  7.17E-02  2.34E-02  2.30E-02  2.28E-02
0.3040 -  0.2960   5.75E-02  5.41E-02  2.57E-02  2.47E-02  0.00E+00  0.00E+00  2.30E-02  0.00E+00
0.2960 -  0.2880   5.75E-02  2.70E-02  7.71E-02  2.47E-02  2.39E-02  2.34E-02  0.00E+00  2.28E-02
0.2880 -  0.2800   0.00E+00  2.70E-02  5.14E-02  0.00E+00  4.78E-02  0.00E+00  0.00E+00  0.00E+00
0.2800 -  0.2720   2.87E-02  5.41E-02  2.57E-02  7.40E-02  9.56E-02  2.34E-02  0.00E+00  2.28E-02
0.2720 -  0.2640   5.75E-02  2.70E-02  1.54E-01  2.47E-02  7.17E-02  2.34E-02  4.60E-02  4.57E-02
0.2640 -  0.2560   1.72E-01  2.70E-02  5.14E-02  9.87E-02  4.78E-02  2.34E-02  4.60E-02  2.28E-02
0.2560 -  0.2480   8.62E-02  5.41E-02  5.14E-02  4.94E-02  7.17E-02  4.67E-02  6.90E-02  0.00E+00
0.2480 -  0.2400   1.44E-01  8.11E-02  1.54E-01  9.87E-02  7.17E-02  2.34E-02  4.60E-02  2.28E-02
0.2400 -  0.2320   8.62E-02  8.11E-02  5.14E-02  7.40E-02  4.78E-02  2.34E-02  2.30E-02  0.00E+00
0.2320 -  0.2240   5.75E-02  1.08E-01  2.06E-01  7.40E-02  2.15E-01  2.34E-02  6.90E-02  0.00E+00
0.2240 -  0.2160   1.15E-01  2.43E-01  5.14E-02  1.48E-01  7.17E-02  7.01E-02  1.15E-01  4.57E-02
0.2160 -  0.2080   2.01E-01  1.35E-01  2.31E-01  7.40E-02  1.91E-01  2.34E-02  0.00E+00  0.00E+00
0.2080 -  0.2000   1.15E-01  0.00E+00  2.57E-02  4.94E-02  9.56E-02  7.01E-02  4.60E-02  2.28E-02
0.2000 -  0.1920   8.62E-02  8.11E-02  1.03E-01  1.48E-01  1.20E-01  4.67E-02  2.30E-02  6.85E-02
0.1920 -  0.1840   2.30E-01  2.70E-01  1.54E-01  4.94E-02  9.56E-02  1.40E-01  0.00E+00  2.28E-02
0.1840 -  0.1760   1.72E-01  1.08E-01  1.29E-01  4.94E-02  1.67E-01  7.01E-02  9.20E-02  4.57E-02
0.1760 -  0.1680   1.72E-01  1.35E-01  1.80E-01  7.41E-02  4.78E-02  0.00E+00  1.15E-01  1.14E-01
0.1680 -  0.1600   8.62E-02  2.16E-01  3.34E-01  9.87E-02  1.20E-01  9.34E-02  6.90E-02  4.57E-02
0.1600 -  0.1520   1.15E-01  8.11E-02  0.00E+00  1.48E-01  0.00E+00  1.17E-01  9.20E-02  4.57E-02
0.1520 -  0.1440   1.44E-01  1.62E-01  1.29E-01  9.87E-02  2.39E-02  7.01E-02  2.30E-02  4.57E-02
0.1440 -  0.1360   5.75E-02  1.62E-01  1.80E-01  1.23E-01  4.78E-02  1.87E-01  2.30E-02  9.13E-02
0.1360 -  0.1280   2.01E-01  8.11E-02  7.71E-02  1.23E-01  9.56E-02  1.40E-01  6.90E-02  2.28E-02
0.1280 -  0.1200   2.01E-01  2.70E-02  1.54E-01  4.94E-02  2.39E-02  0.00E+00  6.90E-02  4.57E-02
0.1200 -  0.1120   8.62E-02  1.62E-01  1.29E-01  1.23E-01  7.17E-02  1.40E-01  2.30E-02  2.28E-02
0.1120 -  0.1040   1.44E-01  0.00E+00  1.29E-01  4.94E-02  1.67E-01  2.34E-02  2.30E-02  2.28E-02
0.1040 -  0.0960   2.30E-01  8.11E-02  1.03E-01  0.00E+00  1.20E-01  4.67E-02  2.30E-02  4.57E-02
0.0960 -  0.0880   1.44E-01  1.62E-01  2.57E-02  9.87E-02  1.43E-01  7.01E-02  4.60E-02  9.13E-02
0.0880 -  0.0800   8.62E-02  2.70E-02  1.03E-01  2.47E-02  7.17E-02  0.00E+00  4.60E-02  0.00E+00
0.0800 -  0.0720   2.30E-01  1.35E-01  1.29E-01  9.87E-02  0.00E+00  4.67E-02  0.00E+00  4.57E-02
0.0720 -  0.0640   1.15E-01  1.89E-01  7.71E-02  7.41E-02  2.39E-02  0.00E+00  6.90E-02  6.85E-02
0.0640 -  0.0560   1.44E-01  1.08E-01  1.80E-01  1.48E-01  4.78E-02  2.34E-02  4.60E-02  2.28E-02
0.0560 -  0.0480   1.72E-01  1.08E-01  5.14E-02  2.47E-02  4.78E-02  2.34E-02  4.60E-02  0.00E+00
0.0480 -  0.0400   1.72E-01  1.35E-01  1.29E-01  7.41E-02  7.17E-02  2.34E-02  4.60E-02  4.57E-02
0.0400 -  0.0320   8.62E-02  1.08E-01  7.71E-02  7.40E-02  7.17E-02  4.67E-02  0.00E+00  0.00E+00
0.0320 -  0.0240   2.87E-02  8.11E-02  2.57E-02  7.40E-02  4.78E-02  4.67E-02  4.60E-02  0.00E+00
0.0240 -  0.0160   1.44E-01  1.35E-01  5.14E-02  7.40E-02  0.00E+00  2.34E-02  0.00E+00  0.00E+00
0.0160 -  0.0080   5.75E-02  1.89E-01  5.14E-02  9.87E-02  0.00E+00  7.01E-02  4.60E-02  0.00E+00
0.0080 -  0.0011   6.62E-02  6.22E-02  0.00E+00  2.84E-02  8.26E-02  5.38E-02  0.00E+00  0.00E+00
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                 ENERGY SPECTRA AND ANGULAR DISTRIBUTIONS OF ELECTRONS REFLECTED FROM
                                      SLAB  4 MADE OF MATERIAL  2
                        (NUMBER/(MEV*SR), NORMALIZED TO ONE INCIDENT PARTICLE)

    E (MEV)  THETA=  0.000     5.000    10.000    15.000    20.000    25.000    30.000    35.000    40.000    45.000
                     5.000    10.000    15.000    20.000    25.000    30.000    35.000    40.000    45.000    50.000

 0.4000 -  0.3920  0.00E+00  0.00E+00  0.00E+00  7.58E-02  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
 0.3920 -  0.3840  0.00E+00  0.00E+00  0.00E+00  7.58E-02  0.00E+00  0.00E+00  0.00E+00  3.75E-02  3.38E-02  3.09E-02
 0.3840 -  0.3760  0.00E+00  1.75E-01  0.00E+00  0.00E+00  5.96E-02  0.00E+00  4.24E-02  3.75E-02  3.38E-02  9.28E-02
 0.3760 -  0.3680  5.23E-01  0.00E+00  0.00E+00  7.58E-02  5.96E-02  4.94E-02  8.49E-02  3.75E-02  3.38E-02  1.24E-01
 0.3680 -  0.3600  0.00E+00  0.00E+00  0.00E+00  7.58E-02  1.19E-01  1.98E-01  8.49E-02  7.49E-02  0.00E+00  9.28E-02
 0.3600 -  0.3520  5.23E-01  3.49E-01  2.11E-01  2.28E-01  3.58E-01  3.46E-01  2.55E-01  2.62E-01  1.69E-01  1.86E-01
 0.3520 -  0.3440  2.09E+00  6.99E-01  8.43E-01  8.34E-01  8.94E-01  6.91E-01  5.09E-01  4.87E-01  6.41E-01  4.02E-01
 0.3440 -  0.3360  3.14E+00  8.74E-01  1.48E+00  1.44E+00  1.67E+00  1.73E+00  1.66E+00  8.99E-01  1.15E+00  1.14E+00
 0.3360 -  0.3280  5.23E-01  2.45E+00  1.79E+00  2.05E+00  2.92E+00  1.68E+00  1.83E+00  1.61E+00  1.72E+00  1.52E+00
 0.3280 -  0.3200  3.66E+00  2.27E+00  2.00E+00  3.26E+00  2.68E+00  2.17E+00  2.46E+00  2.66E+00  1.42E+00  2.20E+00
 0.3200 -  0.3120  2.61E+00  2.27E+00  3.27E+00  3.19E+00  3.52E+00  2.77E+00  2.72E+00  2.25E+00  2.23E+00  2.35E+00
 0.3120 -  0.3040  2.61E+00  4.02E+00  2.95E+00  2.88E+00  3.99E+00  3.16E+00  2.63E+00  2.96E+00  2.57E+00  2.94E+00
 0.3040 -  0.2960  3.66E+00  4.89E+00  3.58E+00  3.72E+00  2.80E+00  3.41E+00  3.69E+00  2.25E+00  3.00E+00  1.79E+00
 0.2960 -  0.2880  3.66E+00  4.72E+00  4.53E+00  3.41E+00  3.64E+00  3.11E+00  2.55E+00  2.66E+00  2.40E+00  1.86E+00
 0.2880 -  0.2800  3.14E+00  4.89E+00  4.11E+00  3.72E+00  3.10E+00  3.80E+00  3.44E+00  2.62E+00  2.77E+00  2.20E+00
 0.2800 -  0.2720  8.36E+00  4.54E+00  4.53E+00  3.87E+00  3.46E+00  3.11E+00  3.14E+00  2.40E+00  2.80E+00  2.01E+00
 0.2720 -  0.2640  3.66E+00  3.32E+00  3.16E+00  3.64E+00  3.46E+00  2.91E+00  3.27E+00  2.32E+00  2.06E+00  2.17E+00
 0.2640 -  0.2560  5.75E+00  4.02E+00  4.32E+00  3.87E+00  3.87E+00  2.72E+00  2.72E+00  2.77E+00  2.23E+00  2.04E+00
 0.2560 -  0.2480  4.71E+00  4.89E+00  3.16E+00  3.56E+00  2.92E+00  3.31E+00  3.23E+00  2.85E+00  2.46E+00  2.20E+00
 0.2480 -  0.2400  2.61E+00  2.97E+00  3.06E+00  3.64E+00  2.68E+00  2.57E+00  2.67E+00  2.36E+00  2.03E+00  1.70E+00
 0.2400 -  0.2320  5.23E+00  3.32E+00  3.06E+00  3.56E+00  3.22E+00  2.96E+00  2.59E+00  2.70E+00  2.30E+00  2.07E+00
 0.2320 -  0.2240  2.61E+00  2.80E+00  2.53E+00  2.12E+00  2.32E+00  2.27E+00  2.12E+00  1.84E+00  2.36E+00  1.79E+00
 0.2240 -  0.2160  4.71E+00  3.32E+00  2.63E+00  3.34E+00  2.74E+00  2.42E+00  2.46E+00  1.76E+00  1.45E+00  1.82E+00
 0.2160 -  0.2080  2.09E+00  1.92E+00  2.21E+00  2.43E+00  1.97E+00  2.42E+00  2.04E+00  1.80E+00  1.62E+00  1.64E+00
 0.2080 -  0.2000  5.23E+00  3.32E+00  3.37E+00  2.50E+00  2.15E+00  1.98E+00  2.33E+00  1.80E+00  1.15E+00  1.58E+00
 0.2000 -  0.1920  5.23E-01  2.10E+00  1.90E+00  2.81E+00  2.09E+00  2.62E+00  1.78E+00  1.61E+00  1.42E+00  1.18E+00
 0.1920 -  0.1840  1.05E+00  2.80E+00  2.42E+00  1.74E+00  1.85E+00  1.68E+00  1.40E+00  1.27E+00  1.55E+00  1.27E+00
 0.1840 -  0.1760  2.09E+00  1.75E+00  2.21E+00  2.20E+00  1.61E+00  1.88E+00  1.10E+00  1.65E+00  1.42E+00  1.42E+00
 0.1760 -  0.1680  1.05E+00  2.10E+00  2.32E+00  1.74E+00  1.79E+00  1.38E+00  1.36E+00  1.12E+00  1.15E+00  9.59E-01
 0.1680 -  0.1600  5.23E-01  3.14E+00  1.26E+00  1.67E+00  1.73E+00  8.89E-01  1.19E+00  8.99E-01  1.32E+00  9.59E-01
 0.1600 -  0.1520  1.05E+00  6.99E-01  1.58E+00  1.74E+00  1.61E+00  1.68E+00  9.76E-01  1.42E+00  1.38E+00  9.59E-01
 0.1520 -  0.1440  5.23E-01  8.74E-01  2.21E+00  1.37E+00  1.37E+00  9.88E-01  1.19E+00  1.20E+00  1.05E+00  6.50E-01
 0.1440 -  0.1360  1.57E+00  8.74E-01  6.32E-01  1.90E+00  1.19E+00  1.33E+00  8.91E-01  8.99E-01  1.05E+00  7.73E-01
 0.1360 -  0.1280  5.23E-01  1.05E+00  7.38E-01  1.06E+00  1.55E+00  1.19E+00  1.06E+00  8.99E-01  6.41E-01  1.05E+00
 0.1280 -  0.1200  1.05E+00  1.40E+00  1.26E+00  8.34E-01  7.75E-01  8.40E-01  1.06E+00  8.62E-01  1.18E+00  7.73E-01
 0.1200 -  0.1120  1.05E+00  5.24E-01  1.58E+00  1.29E+00  1.31E+00  1.04E+00  1.06E+00  7.49E-01  8.44E-01  6.80E-01
 0.1120 -  0.1040  0.00E+00  1.75E-01  1.69E+00  8.34E-01  1.01E+00  1.09E+00  8.06E-01  7.12E-01  8.44E-01  7.73E-01
 0.1040 -  0.0960  5.23E-01  5.24E-01  6.32E-01  8.34E-01  7.75E-01  1.28E+00  8.49E-01  8.99E-01  4.73E-01  6.19E-01
 0.0960 -  0.0880  0.00E+00  6.99E-01  9.48E-01  6.83E-01  9.53E-01  6.91E-01  9.34E-01  7.87E-01  6.41E-01  5.57E-01
 0.0880 -  0.0800  1.57E+00  8.74E-01  9.48E-01  1.06E+00  3.58E-01  7.41E-01  5.94E-01  5.99E-01  5.74E-01  5.57E-01
 0.0800 -  0.0720  1.05E+00  5.24E-01  4.21E-01  2.28E-01  5.96E-01  6.42E-01  1.36E+00  6.37E-01  7.09E-01  6.80E-01
 0.0720 -  0.0640  1.05E+00  6.99E-01  4.21E-01  1.29E+00  7.15E-01  6.42E-01  8.49E-01  4.50E-01  6.08E-01  5.26E-01
 0.0640 -  0.0560  5.23E-01  5.24E-01  5.27E-01  7.58E-01  7.75E-01  4.94E-01  6.37E-01  3.00E-01  6.75E-01  5.57E-01
 0.0560 -  0.0480  0.00E+00  1.75E-01  6.32E-01  5.31E-01  7.75E-01  3.95E-01  5.52E-01  3.75E-01  5.06E-01  6.19E-01
 0.0480 -  0.0400  1.05E+00  5.24E-01  6.32E-01  7.58E-01  4.17E-01  2.96E-01  2.97E-01  4.50E-01  5.74E-01  6.50E-01
 0.0400 -  0.0320  5.23E-01  6.99E-01  3.16E-01  4.55E-01  5.36E-01  4.94E-01  5.09E-01  2.25E-01  4.73E-01  4.64E-01
 0.0320 -  0.0240  1.05E+00  3.49E-01  4.21E-01  0.00E+00  7.75E-01  8.40E-01  2.97E-01  5.62E-01  5.06E-01  3.09E-01
 0.0240 -  0.0160  1.57E+00  5.24E-01  8.43E-01  3.79E-01  5.96E-01  3.95E-01  3.40E-01  4.50E-01  4.05E-01  2.78E-01
 0.0160 -  0.0080  5.23E-01  6.99E-01  5.27E-01  9.10E-01  6.56E-01  4.94E-01  4.24E-01  4.87E-01  5.74E-01  4.02E-01
 0.0080 -  0.0011  1.20E+00  1.01E+00  3.64E-01  9.60E-01  6.86E-01  3.98E-01  3.91E-01  3.88E-01  5.05E-01  7.48E-01
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                    ENERGY SPECTRA AND ANGULAR DISTRIBUTIONS OF ELECTRONS REFLECTED FROM
                                       SLAB  4 MADE OF MATERIAL  2
                          (NUMBER/(MEV*SR), NORMALIZED TO ONE INCIDENT PARTICLE)

   E (MEV)  THETA= 50.000     55.000     60.000     65.000     70.000     75.000     80.000     85.000
                   55.000     60.000     65.000     70.000     75.000     80.000     85.000     90.000

0.4000 -   0.3920   0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.3920 -   0.3840   0.00E+00  0.00E+00  2.57E-02  2.47E-02  0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.3840 -   0.3760   0.00E+00  0.00E+00  5.14E-02  2.47E-02  7.17E-02  2.34E-02  0.00E+00  0.00E+00
0.3760 -   0.3680   5.75E-02  5.41E-02  2.57E-02  4.94E-02  2.39E-02  0.00E+00  4.60E-02  0.00E+00
0.3680 -   0.3600   1.44E-01  1.08E-01  1.54E-01  2.72E-01  7.17E-02  7.01E-02  4.60E-02  4.57E-02
0.3600 -   0.3520   8.62E-02  2.43E-01  2.06E-01  2.22E-01  1.67E-01  1.40E-01  1.15E-01  6.85E-02
0.3520 -   0.3440   7.47E-01  5.41E-01  6.17E-01  3.46E-01  5.26E-01  1.87E-01  2.76E-01  9.13E-02
0.3440 -   0.3360   8.34E-01  1.03E+00  7.20E-01  7.65E-01  4.30E-01  2.80E-01  3.91E-01  2.74E-01
0.3360 -   0.3280   1.18E+00  1.19E+00  1.18E+00  1.04E+00  6.46E-01  4.20E-01  4.14E-01  1.83E-01
0.3280 -   0.3200   1.41E+00  1.38E+00  1.05E+00  7.90E-01  9.33E-01  5.14E-01  4.83E-01  2.28E-01
0.3200 -   0.3120   1.81E+00  1.41E+00  7.97E-01  8.89E-01  8.61E-01  7.94E-01  3.91E-01  2.05E-01
0.3120 -   0.3040   2.07E+00  2.00E+00  1.72E+00  1.18E+00  1.17E+00  8.88E-01  5.98E-01  3.20E-01
0.3040 -   0.2960   2.04E+00  1.76E+00  1.67E+00  1.26E+00  1.22E+00  6.07E-01  6.67E-01  2.05E-01
0.2960 -   0.2880   2.41E+00  1.81E+00  1.90E+00  1.31E+00  6.22E-01  6.07E-01  3.91E-01  2.05E-01
0.2880 -   0.2800   2.01E+00  1.95E+00  1.44E+00  1.36E+00  1.10E+00  6.54E-01  6.21E-01  3.42E-01
0.2800 -   0.2720   1.81E+00  1.84E+00  1.70E+00  1.09E+00  9.56E-01  5.37E-01  4.60E-01  3.20E-01
0.2720 -   0.2640   1.95E+00  1.76E+00  1.16E+00  1.18E+00  9.09E-01  6.31E-01  4.37E-01  1.14E-01
0.2640 -   0.2560   2.01E+00  1.68E+00  1.36E+00  1.28E+00  9.80E-01  6.77E-01  4.60E-01  1.83E-01
0.2560 -   0.2480   1.58E+00  1.68E+00  1.47E+00  9.38E-01  9.80E-01  7.01E-01  3.91E-01  2.05E-01
0.2480 -   0.2400   2.27E+00  1.68E+00  1.34E+00  1.26E+00  9.80E-01  5.37E-01  4.83E-01  3.42E-01
0.2400 -   0.2320   1.61E+00  1.27E+00  1.36E+00  1.09E+00  7.65E-01  5.84E-01  3.45E-01  2.51E-01
0.2320 -   0.2240   1.41E+00  1.38E+00  1.05E+00  1.06E+00  8.13E-01  4.44E-01  4.37E-01  2.51E-01
0.2240 -   0.2160   1.32E+00  1.11E+00  1.16E+00  1.23E+00  5.98E-01  5.84E-01  3.45E-01  1.60E-01
0.2160 -   0.2080   1.38E+00  1.27E+00  1.16E+00  8.89E-01  8.13E-01  6.54E-01  3.68E-01  1.60E-01
0.2080 -   0.2000   1.03E+00  1.27E+00  1.13E+00  8.89E-01  6.46E-01  4.67E-01  4.14E-01  1.14E-01
0.2000 -   0.1920   1.41E+00  1.19E+00  7.97E-01  5.68E-01  5.98E-01  5.84E-01  3.68E-01  2.74E-01
0.1920 -   0.1840   1.15E+00  6.22E-01  8.48E-01  6.17E-01  5.02E-01  3.50E-01  3.22E-01  2.97E-01
0.1840 -   0.1760   1.09E+00  1.03E+00  9.77E-01  8.64E-01  7.17E-01  3.97E-01  2.30E-01  2.74E-01
0.1760 -   0.1680   1.06E+00  7.84E-01  6.68E-01  9.13E-01  6.46E-01  3.27E-01  3.45E-01  2.28E-01
0.1680 -   0.1600   8.05E-01  1.08E+00  7.20E-01  6.17E-01  4.06E-01  3.04E-01  2.30E-01  3.20E-01
0.1600 -   0.1520   9.49E-01  7.03E-01  8.74E-01  6.66E-01  4.78E-01  5.84E-01  2.30E-01  9.13E-02
0.1520 -   0.1440   9.77E-01  6.22E-01  5.91E-01  6.17E-01  4.06E-01  2.10E-01  1.61E-01  1.83E-01
0.1440 -   0.1360   9.77E-01  7.84E-01  4.11E-01  4.94E-01  4.78E-01  1.87E-01  1.15E-01  9.13E-02
0.1360 -   0.1280   4.60E-01  4.87E-01  6.17E-01  4.44E-01  1.67E-01  1.87E-01  1.38E-01  9.13E-02
0.1280 -   0.1200   7.76E-01  5.41E-01  4.63E-01  4.20E-01  3.83E-01  2.34E-01  1.84E-01  1.14E-01
0.1200 -   0.1120   7.47E-01  8.65E-01  6.17E-01  5.92E-01  3.59E-01  1.64E-01  2.07E-01  6.85E-02
0.1120 -   0.1040   5.75E-01  6.22E-01  5.14E-01  2.47E-01  7.17E-02  1.64E-01  1.61E-01  4.57E-02
0.1040 -   0.0960   4.31E-01  4.87E-01  3.60E-01  3.70E-01  4.30E-01  3.04E-01  9.20E-02  1.14E-01
0.0960 -   0.0880   6.04E-01  4.06E-01  4.63E-01  2.72E-01  1.67E-01  1.40E-01  2.07E-01  6.85E-02
0.0880 -   0.0800   6.32E-01  4.87E-01  4.63E-01  3.70E-01  2.15E-01  2.10E-01  9.20E-02  1.14E-01
0.0800 -   0.0720   4.31E-01  5.41E-01  3.86E-01  3.21E-01  3.83E-01  2.80E-01  1.61E-01  4.57E-02
0.0720 -   0.0640   4.02E-01  3.24E-01  3.60E-01  2.96E-01  1.67E-01  2.34E-01  1.15E-01  6.85E-02
0.0640 -   0.0560   3.74E-01  2.70E-01  3.86E-01  2.72E-01  1.67E-01  1.17E-01  1.38E-01  6.85E-02
0.0560 -   0.0480   5.17E-01  4.87E-01  3.60E-01  2.47E-01  1.43E-01  3.04E-01  1.61E-01  0.00E+00
0.0480 -   0.0400   3.16E-01  2.97E-01  2.83E-01  1.97E-01  9.56E-02  1.17E-01  1.15E-01  4.57E-02
0.0400 -   0.0320   3.16E-01  2.16E-01  2.83E-01  1.23E-01  1.67E-01  1.40E-01  6.90E-02  4.57E-02
0.0320 -   0.0240   3.16E-01  1.89E-01  1.29E-01  2.96E-01  7.17E-02  1.64E-01  1.15E-01  6.85E-02
0.0240 -   0.0160   4.02E-01  4.33E-01  2.83E-01  1.73E-01  1.67E-01  1.40E-01  9.20E-02  0.00E+00
0.0160 -   0.0080   5.46E-01  3.52E-01  3.60E-01  1.73E-01  2.15E-01  1.64E-01  6.90E-02  6.85E-02
0.0080 -   0.0011   3.64E-01  2.18E-01  3.55E-01  1.99E-01  1.93E-01  8.07E-02  1.59E-01  2.63E-02
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                                           ENERGY SPECTRA OF TRANSMITTED PHOTONS
                                      (NUMBER/MEV, NORMALIZED TO ONE INCIDENT PARTICLE)

                 MATERIAL  1          3          4          2

      E (MEV)        Z=1.15E-02  2.36E-02   2.94E-02   2.79E-01

0.4000 -   0.3920   0.00E+00   0.00E+00   0.00E+00   0.00E+00
0.3920 -   0.3840   0.00E+00   0.00E+00   0.00E+00   0.00E+00
0.3840 -   0.3760   0.00E+00   0.00E+00   0.00E+00   0.00E+00
0.3760 -   0.3680   0.00E+00   0.00E+00   0.00E+00   0.00E+00
0.3680 -   0.3600   0.00E+00   0.00E+00   0.00E+00   0.00E+00
0.3600 -   0.3520   0.00E+00   0.00E+00   0.00E+00   0.00E+00
0.3520 -   0.3440   0.00E+00   0.00E+00   0.00E+00   0.00E+00
0.3440 -   0.3360   0.00E+00   0.00E+00   0.00E+00   0.00E+00
0.3360 -   0.3280   0.00E+00   0.00E+00   0.00E+00   0.00E+00
0.3280 -   0.3200   0.00E+00   0.00E+00   0.00E+00   0.00E+00
0.3200 -   0.3120   0.00E+00   0.00E+00   0.00E+00   0.00E+00
0.3120 -   0.3040   0.00E+00   0.00E+00   0.00E+00   0.00E+00
0.3040 -   0.2960   0.00E+00   0.00E+00   0.00E+00   0.00E+00
0.2960 -   0.2880   0.00E+00   0.00E+00   0.00E+00   0.00E+00
0.2880 -   0.2800   0.00E+00   0.00E+00   0.00E+00   0.00E+00
0.2800 -   0.2720   0.00E+00   0.00E+00   0.00E+00   0.00E+00
0.2720 -   0.2640   0.00E+00   0.00E+00   0.00E+00   8.97E-03
0.2640 -   0.2560   0.00E+00   0.00E+00   0.00E+00   0.00E+00
0.2560 -   0.2480   0.00E+00   0.00E+00   0.00E+00   0.00E+00
0.2480 -   0.2400   0.00E+00   0.00E+00   0.00E+00   9.00E-03
0.2400 -   0.2320   0.00E+00   0.00E+00   0.00E+00   3.71E-02
0.2320 -   0.2240   0.00E+00   0.00E+00   0.00E+00   1.52E-02
0.2240 -   0.2160   0.00E+00   0.00E+00   0.00E+00   8.55E-03
0.2160 -   0.2080   0.00E+00   0.00E+00   0.00E+00   1.21E-02
0.2080 -   0.2000   0.00E+00   0.00E+00   0.00E+00   1.76E-02
0.2000 -   0.1920   0.00E+00   0.00E+00   0.00E+00   2.86E-02
0.1920 -   0.1840   1.25E-02   1.25E-02   1.25E-02   5.70E-02
0.1840 -   0.1760   0.00E+00   0.00E+00   0.00E+00   3.80E-02
0.1760 -   0.1680   0.00E+00   0.00E+00   0.00E+00   4.04E-02
0.1680 -   0.1600   0.00E+00   0.00E+00   0.00E+00   1.34E-02
0.1600 -   0.1520   0.00E+00   0.00E+00   1.25E-02   3.72E-02
0.1520 -   0.1440   0.00E+00   1.25E-02   1.25E-02   1.62E-02
0.1440 -   0.1360   0.00E+00   1.25E-02   1.24E-02   2.00E-02
0.1360 -   0.1280   1.25E-02   2.49E-02   2.48E-02   1.61E-02
0.1280 -   0.1200   1.25E-02   3.74E-02   3.74E-02   1.07E-02
0.1200 -   0.1120   1.25E-02   1.25E-02   1.25E-02   3.61E-02
0.1120 -   0.1040   0.00E+00   0.00E+00   0.00E+00   4.43E-02
0.1040 -   0.0960   0.00E+00   0.00E+00   0.00E+00   4.53E-02
0.0960 -   0.0880   1.25E-02   1.25E-02   1.24E-02   1.77E-01
0.0880 -   0.0800   0.00E+00   0.00E+00   0.00E+00   6.28E-03
0.0800 -   0.0720   3.73E-02   3.70E-02   3.69E-02   2.02E-02
0.0720 -   0.0640   1.24E-02   1.24E-02   1.23E-02   3.33E-02
0.0640 -   0.0560   0.00E+00   0.00E+00   1.25E-02   1.31E-02
0.0560 -   0.0480   0.00E+00   0.00E+00   0.00E+00   8.75E-03
0.0480 -   0.0400   1.22E-02   1.22E-02   3.72E-02   4.53E-03
0.0400 -   0.0320   1.22E-02   3.72E-02   3.71E-02   7.04E-04
0.0320 -   0.0240   3.56E-02   5.98E-02   7.18E-02   3.46E-06
0.0240 -   0.0160   5.85E-02   6.97E-02   8.16E-02   3.29E-07
0.0160 -   0.0100   6.51E-02   1.58E-01   1.55E-01   1.39E-08
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                                  ENERGY SPECTRA OF REFLECTED PHOTONS
                            (NUMBER/MEV, NORMALIZED TO ONE INCIDENT PARTICLE)

               MATERIAL  1         3         4         2

    E (MEV)       Z=0.00E+00  1.15E-02  2.36E-02  2.94E-02

0.4000 -  0.3920   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.3920 -  0.3840   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.3840 -  0.3760   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.3760 -  0.3680   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.3680 -  0.3600   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.3600 -  0.3520   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.3520 -  0.3440   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.3440 -  0.3360   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.3360 -  0.3280   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.3280 -  0.3200   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.3200 -  0.3120   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.3120 -  0.3040   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.3040 -  0.2960   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.2960 -  0.2880   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.2880 -  0.2800   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.2800 -  0.2720   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.2720 -  0.2640   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.2640 -  0.2560   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.2560 -  0.2480   2.19E-02  2.20E-02  2.22E-02  2.22E-02
0.2480 -  0.2400   1.06E-02  1.07E-02  1.07E-02  1.08E-02
0.2400 -  0.2320   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.2320 -  0.2240   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.2240 -  0.2160   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.2160 -  0.2080   0.00E+00  0.00E+00  0.00E+00  0.00E+00
0.2080 -  0.2000   2.24E-02  2.27E-02  2.30E-02  2.31E-02
0.2000 -  0.1920   1.91E-02  1.99E-02  2.08E-02  2.13E-02
0.1920 -  0.1840   4.30E-02  4.34E-02  4.39E-02  4.41E-02
0.1840 -  0.1760   2.65E-02  2.70E-02  2.75E-02  2.77E-02
0.1760 -  0.1680   3.40E-02  3.42E-02  3.43E-02  3.44E-02
0.1680 -  0.1600   3.61E-02  3.63E-02  3.64E-02  3.64E-02
0.1600 -  0.1520   2.34E-02  2.35E-02  2.36E-02  2.36E-02
0.1520 -  0.1440   2.99E-02  3.04E-02  3.10E-02  3.12E-02
0.1440 -  0.1360   6.81E-02  6.86E-02  6.91E-02  6.93E-02
0.1360 -  0.1280   9.46E-03  9.51E-03  9.54E-03  9.56E-03
0.1280 -  0.1200   3.05E-02  3.13E-02  1.92E-02  1.92E-02
0.1200 -  0.1120   1.89E-02  1.90E-02  1.91E-02  1.91E-02
0.1120 -  0.1040   2.50E-01  2.51E-01  2.51E-01  2.52E-01
0.1040 -  0.0960   1.12E-01  1.13E-01  1.13E-01  1.13E-01
0.0960 -  0.0880   7.84E-02  7.92E-02  7.96E-02  7.98E-02
0.0880 -  0.0800   8.60E-02  7.44E-02  7.49E-02  7.51E-02
0.0800 -  0.0720   6.40E-02  6.48E-02  6.51E-02  6.53E-02
0.0720 -  0.0640   1.64E-01  1.56E-01  1.45E-01  1.45E-01
0.0640 -  0.0560   8.76E-02  8.98E-02  9.04E-02  9.06E-02
0.0560 -  0.0480   1.60E-01  1.44E-01  1.46E-01  1.47E-01
0.0480 -  0.0400   9.14E-02  9.59E-02  9.65E-02  9.67E-02
0.0400 -  0.0320   1.51E-01  1.39E-01  1.40E-01  1.41E-01
0.0320 -  0.0240   1.73E-01  1.42E-01  1.18E-01  1.06E-01
0.0240 -  0.0160   2.21E-01  2.85E-01  2.53E-01  2.29E-01
0.0160 -  0.0100   1.58E-01  2.92E-01  2.44E-01  2.30E-01
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                        ANGULAR DISTRIBUTIONS OF TRANSMITTED PHOTON INTENSITY
                           (MEV/SR, NORMALIZED TO ONE INCIDENT PARTICLE)

                  MATERIAL  1         3         4         2

   THETA (DEG)     Z=1.15E-02  2.36E-02  2.94E-02  2.79E-01

  0.0000 -  5.0000   0.00E+00  0.00E+00  0.00E+00  4.27E-05
  5.0000 - 10.0000   1.45E-04  1.44E-04  1.44E-04  7.26E-05
 10.0000 - 15.0000   1.02E-04  1.02E-04  1.02E-04  8.11E-05
 15.0000 - 20.0000   7.17E-05  7.16E-05  7.15E-05  3.48E-04
 20.0000 - 25.0000   4.44E-06  1.05E-05  2.34E-05  1.01E-04
 25.0000 - 30.0000   3.41E-05  4.81E-05  6.69E-05  4.88E-05
 30.0000 - 35.0000   0.00E+00  5.02E-05  6.48E-05  1.52E-04
 35.0000 - 40.0000   1.81E-05  5.76E-05  5.75E-05  3.29E-04
 40.0000 - 45.0000   9.16E-05  9.42E-05  9.40E-05  2.95E-04
 45.0000 - 50.0000   6.97E-06  6.88E-06  2.15E-05  3.26E-04
 50.0000 - 55.0000   2.97E-05  4.04E-05  4.03E-05  2.58E-04
 55.0000 - 60.0000   0.00E+00  0.00E+00  3.36E-05  2.20E-04
 60.0000 - 65.0000   0.00E+00  6.43E-06  6.41E-06  7.10E-05
 65.0000 - 70.0000   1.27E-05  3.89E-05  3.88E-05  5.10E-05
 70.0000 - 75.0000   2.49E-06  2.31E-06  2.27E-06  4.49E-05
 75.0000 - 80.0000   2.84E-05  8.22E-05  8.19E-05  7.84E-05
 80.0000 - 85.0000   0.00E+00  1.69E-06  4.44E-06  3.33E-05
 85.0000 - 90.0000   1.14E-06  5.66E-06  5.48E-06  2.86E-07
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                                 ANGULAR DISTRIBUTIONS OF REFLECTED PHOTON INTENSITY
                                    (MEV/SR, NORMALIZED TO ONE INCIDENT PARTICLE)

              MATERIAL  1         3         4          2

   THETA (DEG)    Z=0.00E+00  1.15E-02  2.36E-02  2.94E-02

 0.0000 -  5.0000   5.74E-04  5.77E-04  5.78E-04  5.79E-04
 5.0000 - 10.0000   1.56E-03  1.57E-03  1.58E-03  1.58E-03
10.0000 - 15.0000   1.48E-05  2.06E-05  2.09E-05  2.09E-05
15.0000 - 20.0000   1.58E-05  5.43E-06  5.52E-06  5.54E-06
20.0000 - 25.0000   1.70E-04  1.36E-04  1.37E-04  1.37E-04
25.0000 - 30.0000   1.50E-04  1.13E-04  1.03E-04  1.03E-04
30.0000 - 35.0000   1.13E-04  1.06E-04  8.60E-05  7.64E-05
35.0000 - 40.0000   6.27E-05  6.50E-05  6.25E-05  5.68E-05
40.0000 - 45.0000   1.68E-04  1.57E-04  1.54E-04  1.54E-04
45.0000 - 50.0000   4.68E-04  4.76E-04  4.78E-04  4.79E-04
50.0000 - 55.0000   2.03E-04  2.01E-04  2.02E-04  2.03E-04
55.0000 - 60.0000   8.55E-05  8.20E-05  7.77E-05  7.79E-05
60.0000 - 65.0000   1.97E-04  2.03E-04  2.04E-04  2.04E-04
65.0000 - 70.0000   1.83E-04  1.88E-04  1.89E-04  1.86E-04
70.0000 - 75.0000   2.99E-04  3.09E-04  3.08E-04  3.09E-04
75.0000 - 80.0000   2.56E-04  2.57E-04  2.48E-04  2.46E-04
80.0000 - 85.0000   2.77E-04  2.88E-04  2.91E-04  2.93E-04
85.0000 - 90.0000   1.42E-04  1.53E-04  1.37E-04  1.40E-04


                                                                    TOTAL TIME =   5.32 MIN (CPU =   5.23, IO =   0.08)
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NBS-114A (REV. 2-80)

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ELECTRON AND PHOTON TRANSPORT IN MULTI-LAYER MEDIA:
NOTES ON THE MONTE CARLO CODE ZTRAN

5. AUTHOR(S)

S. M. Seltzer and M. J. Berger

6. PERFORMING ORGANIZATION *(If joint or other than NBS, see instructions)*

NATIONAL BUREAU OF STANDARDS
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10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)*

This report provides a brief description and running instructions for the one-dimensional Monte Carlo code ZTRAN. The program is used to calculate the transport of electrons and photons in heterogeneous multi-layer media.

12. KEY WORDS *(Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)*

calculations; electrons; Monte Carlo; multi-layer media; photons; transport

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